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AN APPRAISAL OF WATER POLLUTION IN THE LAKE SUPERIOR BASIN

Federal Water Pollution Control Administration
Chicago, Illinois

January 1970

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an appraisal of water pollution in the lake Superior basin

APRIL 1969

(Revised January 1970)

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION

60

FOREWORD

"Lake Superior is apart from the other Great Lakes – it is the storied 'Shining Big Sea Water,' the symbol, the spirit of an intrinsic part of the [American] heritage. To those individuals fortunate enough to have witnessed the crashing of great seas on age-old rock, or the chilling, quiet blanket of fog suddenly lifting to the near blinding of a blue-white summer day; to have seen water so clear that the phantom trout were visible at 5 fathoms; to have experienced the purity that is the Big Lake – to them there is no need to justify any conservation effort on behalf of Lake Superior."

Adapted from Michigan Water Resources Commission
"Water Resource Uses, Present and Prospective
for Lake Superior and the St. Mary's River,"
June 1967

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PREFACE TO REVISED EDITION

This document was first issued in April 1969, in advance of the conference in the matter of pollution of the interstate waters of Lake Superior and its tributary basin as further identified in the Introduction.

To meet the continuing need for copies to provide information for the many people interested in the subject, the report has been reprinted in this revised edition.

Principal changes in this revised edition are as follows:

Chapter VI, Summary and Conclusions and Chapter VII, Recommendations in the original have been deleted and replaced by the SUMMARY OF CONFERENCE. . ., beginning on page 46 of this edition. This Summary contains the conclusions and recommendations unanimously agreed upon by the conferees and approved by the Secretary of the Interior on January 26, 1970.

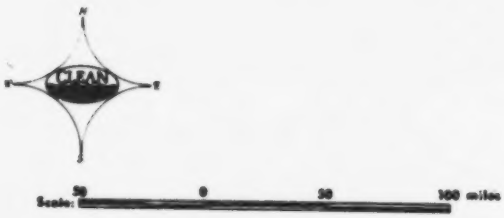
Appendices A, B and C in the original edition have been deleted. Appendix A consisted of a listing of waste treatment facilities for all municipal and industrial discharges plus waste treatment facilities at Federal installations located in the drainage basin. Appendix B presented a summary table of water quality criteria and designated uses for the open waters of Lake Superior as established by Michigan, Minnesota and Wisconsin. Appendix C contained the rationale for the proposed water quality criteria as shown on Table 3, page 44 of this report. Copies of the Appendices are available upon request to the FWPCA Great Lakes Regional Office.

I. INTRODUCTION

On the basis of reports, surveys and studies indicating that interstate pollution is occurring, and in accordance with Section 10 of the Federal Water Pollution Control Act (33 U.S.C. 466 et. seq.) Secretary of the Interior Stewart L. Udall called a Conference in the Matter of Pollution of the Waters of Lake Superior and Its Tributary Basin (Michigan-Minnesota-Wisconsin). The area covered by the conference is shown on Figure 1.

This report was prepared for the information of the conferees and other interested parties, and for use by the conferees in their consideration of actions needed to preserve the high quality of waters in the conference area and improve presently degraded waters. The report is based on studies and investigations by the Federal Water Pollution Control Administration (FWPCA), investigations made through cooperative agreements by other agencies of the Department of the Interior, studies and reports furnished by the three Lake Superior States and information obtained from other Federal agencies, universities, and others. All data presented in this report are for the United States portion of the Lake Superior basin, unless otherwise noted.

The contributions of all who have provided assistance and information is gratefully acknowledged.



LAKE SUPERIOR BASIN

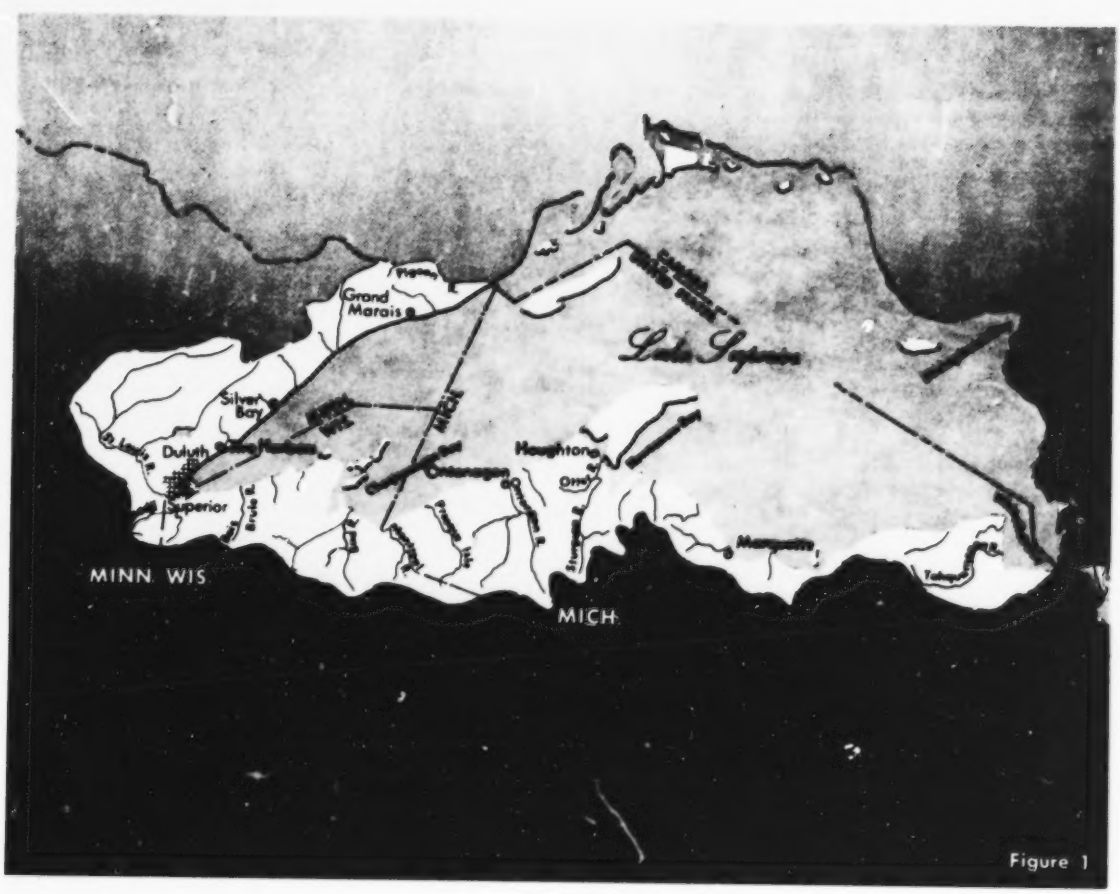


Figure 1

II. THE BASIN AND ITS FEATURES

GENERAL DESCRIPTION

The largest body of fresh water on the earth is comprised in the five Great Lakes covering 95,170 square miles water surface area. Lake Superior is the largest of the Great Lakes and the largest lake in the world – 31,820 square miles in surface area, approximately 350 miles long, 160 miles wide, 1,333 feet maximum depth, and a volume of approximately 3,000 cubic miles. Other physical data concerning Lake Superior are shown on the following table.

	Total	Canada (Ontario)	United States	Mich.	Minn.	Wisc.
Drainage Basin (sq. mi.)	80,511	42,570	37,941	23,931	8,354	5,656
Water Surface (sq. mi.)	31,820	10,702	21,118	16,231	2,212	2,675
Land Area (sq. mi.)	48,691	31,868	16,823	7,700	6,142	2,981
Shoreline (miles)	2,976	1,549	1,427	913	189	325

The topography of the basin, in general, is rough and with certain exceptions, the lake is surrounded by a ridge 400 to 800 feet high. In most areas the highland is either immediately adjacent to the shoreline or close to it. The Wisconsin-Michigan area along the southern shore rises less abruptly, but the height of the ridge is about the same as in Minnesota.

The soil has developed from glacial debris and shallow-lying bedrock. It is a mixture of sand and sandy loam to clay. The low soil fertility and the short growing season are not favorable for extensive agricultural activities.

The climate of the basin is continental in the interior, while a modified marine climate is found near the lake shore and particularly in the peninsular areas. These two distinct types of climate are reflected in the temperatures, precipitation, and growing seasons. Extreme temperatures range from -47°F. to 106°F., while the basin's average temperatures range from 8°F. to 12°F. for January, and 60°F. to 66°F. for July. The average annual precipitation is 28 to 32 inches with 16 to 19 inches falling during the warm season. Snowfall varies from 55 inches to 276 inches in different portions of the basin, and the growing season, which also reflects the wide climate range, varies from 80 to 130 days in the basin.

The principal river of the basin is the St. Louis which has a drainage area of about 3,700 square miles and is an interstate stream that forms part of the Minnesota-Wisconsin boundary. A portion of the Michigan-Wisconsin boundary is formed by the interstate Montreal River, one of the smaller streams in the basin draining an area of about 281 square miles. The boundary between Minnesota and the Province of Ontario, Canada, is formed by the Pigeon River. Other principal rivers are the Bad River in Wisconsin and the Ontonagon River in Michigan.

POPULATION CENTERS

LEGEND:

- ● 100,000
- ■ 20,000 - 50,000
- ▲ 10,000 - 20,000
- △ 5,000 - 10,000

Figure 2

POPULATION

The population density in the United States portion of the basin is low, 30 people per square mile. Approximately a half-million people live in the basin with Minnesota counties (primarily St. Louis County) accounting for about half of the total population. Michigan and Wisconsin counties account for about 34 percent and 16 percent, respectively. The major cities in the Lake Superior watershed with their 1960 populations are: Minnesota, Duluth - 106,884, Hibbing - 17,731, and Virginia - 14,034; Wisconsin, Superior - 33,563, Ashland - 10,132; Michigan, Marquette - 19,824 and Ironwood - 10,265. Figure 2 shows these population centers.

Even though during the past 20 years there has been a considerable emigration from the Lake Superior basin, the population is expected to increase by approximately 100,000 in about two decades with the municipal portion of the population experiencing most of this increase at the expense of the rural areas. The areas most likely to show relatively rapid growth are: Chippewa and Marquette Counties in Michigan, Douglas County in Wisconsin, and St. Louis County in Minnesota. Carlton and Lake Counties, which border on St. Louis County, will experience some of the expansion trend of that county.

Duluth, Minnesota at the head of Lake Superior is the largest city in the basin.

INDUSTRIAL CENTERS

LEGEND:

- Food and kindred products
- Paper and allied products
- Chemical and allied products
- Petroleum and coal products
- Primary metal industries
- Metal mining

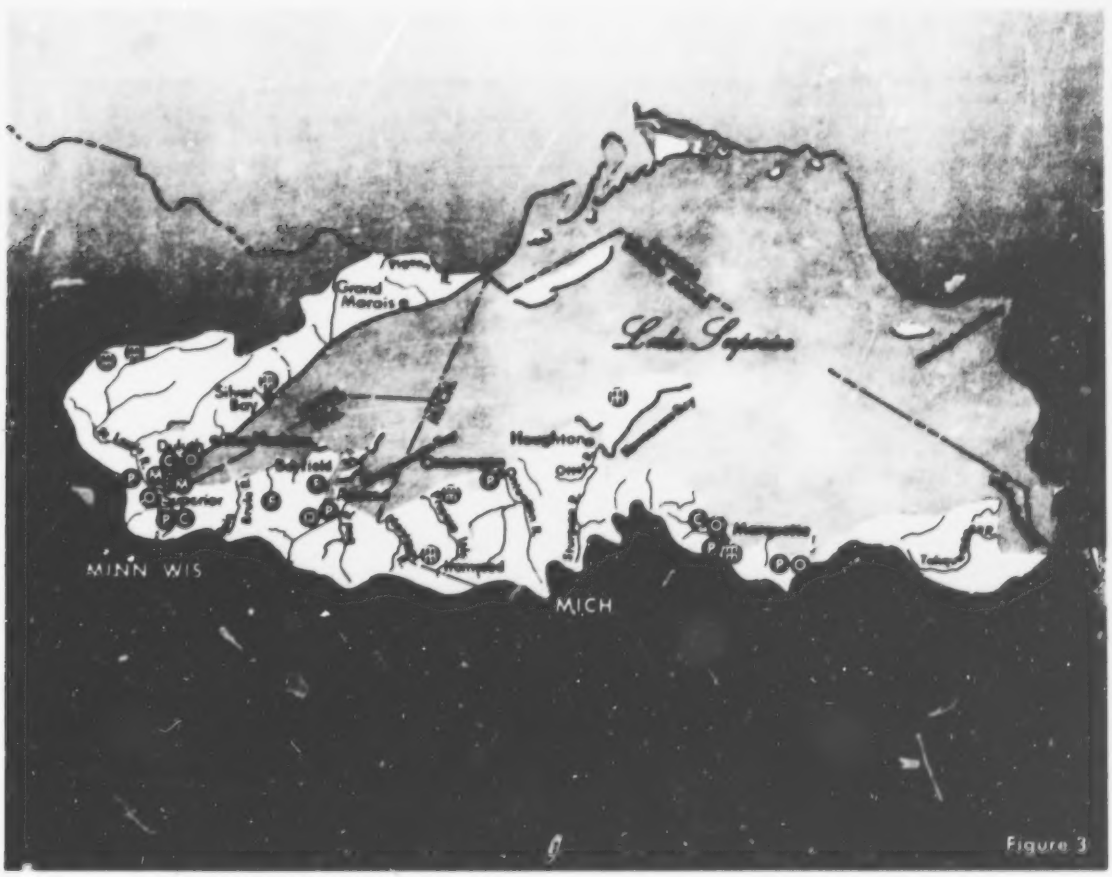


Figure 3

ECONOMY

While the economy of the basin has in the past few decades been uncertain, developments in recent years favor a general uptrend in activity. Continued research activities relating to iron ore processing, dramatic developments in processing of taconite ores, plus progress in research concerning the use of timber resources is creating a new confidence in the future.

Industrial activity in the watershed is diversified both in character as well as location. Figure 3 shows the principal centers of industrial activity. While iron ore mining is the dominant feature of the watershed, value added by manufacture amounted to approximately $250 million in 1963. Duluth – Superior is the major industrial center, but, significant industrial developments are located elsewhere, such as Silver Bay, Minnesota; Ashland, Wisconsin; and Houghton-Hancock, Michigan.

The history of iron ore mining is closely associated with the development of the iron range area of the basin. With the advent of the taconite process whereby low grade iron ore undergoes a beneficiation process to produce pellets containing a higher concentration of iron, the iron mining industry in the basin has economically taken a sharp upturn. As of 1966 pelletized iron ore was firmly established as the most desired form of blast furnace feed in the United States. Taconite beneficiation plants have been established at a number of locations in Minnesota, Michigan, with a potential for their establishment in Wisconsin.

Other mining activities, primarily sand and gravel, are widespread throughout the basin. Copper mining is an important segment of Michigan's economy in the upper peninsula.

Forestry and forest products manufacturing are important in a number of locations in the Lake Superior basin. Virgin timber stands have been greatly depleted but sustained lumbering, pulp logging and Christmas tree harvesting continue to be important contributors to the economy. New technology in processing wood products should enable the area to capitalize to a greater degree on the extensive forest resources. Considerable expansion of the paper and allied products industry is likely.

Some manufacturing activity occurs in all counties of the watershed although in 1963 St. Louis and Carlton Counties of Minnesota and Douglas County in Wisconsin accounted for 70 percent of the total. Manufacturing output is expected to triple in the next 20 to 25 years. Petroleum refining, chemicals, steel rolling and finishing, and food and kindred products are the major categories having installations within the watershed.

Although agriculture is not a major land use, farms are scattered throughout the basin and in some limited areas farming is a dominant feature.

Some of the Nation's most unique and scenic shoreline is a part of the Lake Superior coast line. The wide sand beaches of Whitefish Bay, the great perched dunes near Grand Marais, the sheer cliffs of the Pictured Rocks, the remoteness of the Huron Mountains, the Apostle Islands, Split Rock Lighthouse, Isle Royale National Park and all the many miles of primeval wilderness constitute a most valuable recreation and esthetic resource. Therefore, recreation resources including commercial resorts are very important to the economy and are expected to have even greater significance in the future as a greater number of people from locations outside of the area seek to utilize its existing and planned recreation facilities. An estimated $50 million was spent in the basin on tourism in 1964 (44). It can be assumed this is a conservative figure based upon estimates of growth for the tourism industry.

The use of high quality water extends beyond the bounds of physical contact with the resource. Here towering cliffs and spectacular shoreline provide scenic enjoyment.

WATERBORNE COMMERCE

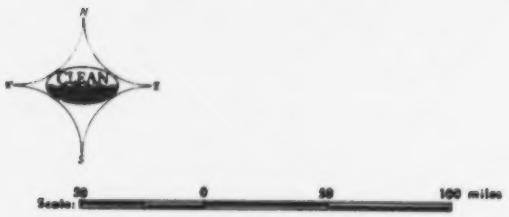
The economy of the Lake Superior basin is naturally stimulated by the presence of the lake. The "fourth seacoast" of the United States and Canada became a reality upon completion of the St. Lawrence Seaway in 1959. There is now a continuous channel from the Great Lakes to the Atlantic Ocean making an ocean port of every deep draft harbor situated on Lake Superior.

The Soo Locks at Sault Ste. Marie and navigable channels of the St. Mary's River are of major importance to commercial navigation in Lake Superior. This busy channel passes approximately 100 million tons of freight annually. With the deep connecting channels and harbors and the new lock (1,200 feet long, 105 feet wide) at Sault Ste. Marie, vessels 1,000 feet in length and 100 feet wide with carrying capacities of 50,000 tons can now be accommodated. Major commodities shipped include iron ore, coal, grain and stone.

The harbor facilities of Lake Superior are also a major asset to the continuing development of the natural resources potential of the basin. The Duluth-Superior port is one of the largest inland shipping ports for waterborne commerce on the Great Lakes. The harbor is the fifth largest in the United States in tonnage, surpassed only by New York Harbor, New Orleans, Houston Harbor and Channel, and the Philadelphia Harbor. Total tonnage exceeds 46 million net tons annually. Annual direct overseas imports and exports total over 3 million tons and consist of more thar one-third of the direct overseas commerce from all Great Lakes ports. The facilities of the Duluth-Superior harbor, which include the largest ore docks in the world, handle the majority of the iron ore which is shipped to the steel mills of the lower lakes. Approximately three-fourths of the total tonnage at the port consists of iron ore. Other major commodities are grain, coal, limestone, cement, scrap iron, iron and steel products, salt, petroleum products, and general merchandise.

In addition to the outstanding facilities at Duluth-Superior there are other commercial harbors throughout the area, including Two Harbors, Silver Bay, Taconite and Grand Marais in Minnesota; Ashland in Wisconsin; and Ontonagon, Keweenaw, Presque Isle, Marquette and Grand Marais in Michigan. Figure 4 depicts the commercial harbors on Lake Superior.

Facilities of the Duluth-Superior Harbor include the largest ore docks in the world. Above is an ore boat entering the harbor.



COMMERCIAL HARBORS

LEGEND:
■ Harbors

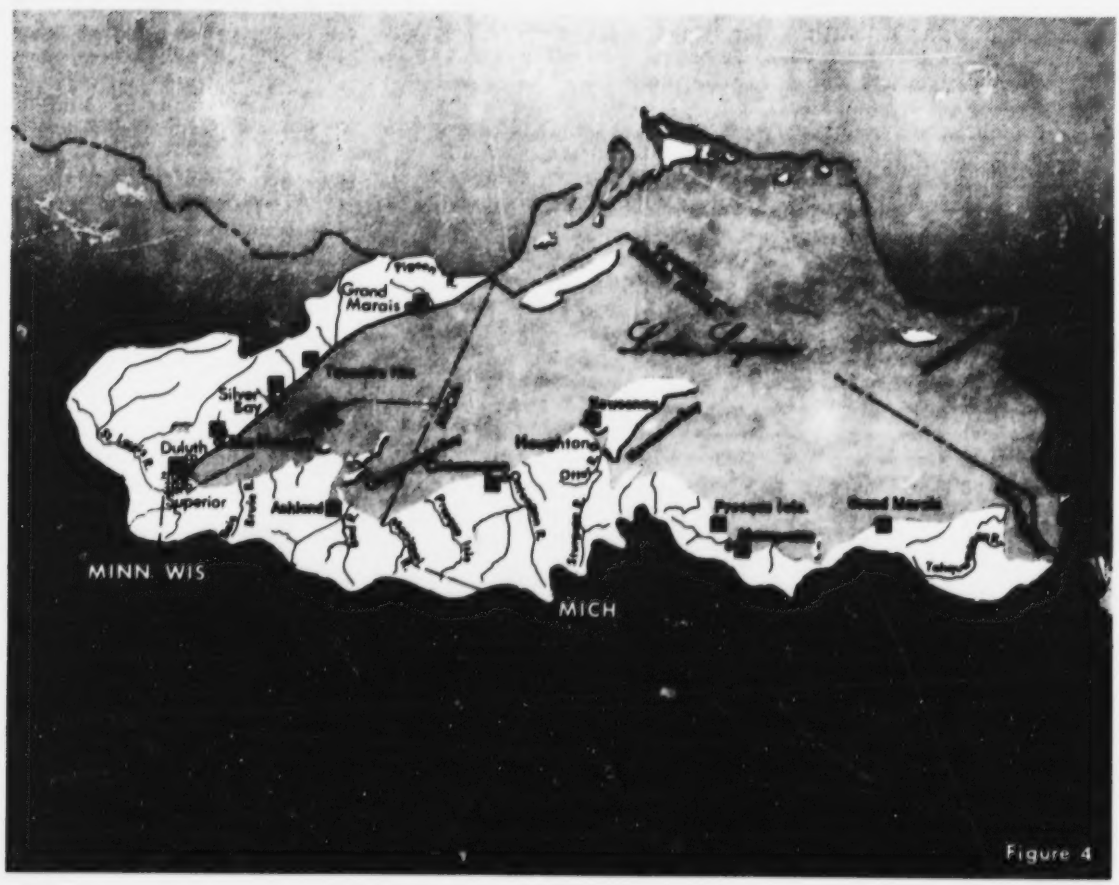


Figure 4

WATER RESOURCES

Lake Superior is the largest of the Great Lakes and in terms of surface area is the largest fresh water lake in the world. In terms of volume of water it is the world's second largest fresh water lake. The average flow out of Lake Superior is 73,100 cubic feet per second (cfs).

Since 1922 the level of Lake Superior has been regulated by operations of control works in the St. Mary's River above the rapids at Sault Ste. Marie. (47) These works, including a 16-gate control structure, powerhouses and canals and locks, were built as a condition of an order of the International Joint Commission granting a permit to divert water around the rapids for power generation (to prevent lowering of Lake Superior). The same order also created an International Lake Superior Board of Control, consisting of an officer of the Corps of Engineers and an officer appointed by the Canadian government.

It is the function of the Board to determine the amount of water available for power generation and to maintain as nearly as possible the level of Lake Superior to its low datum of 600 feet. Since 1957, the level of Lake Superior from extreme low to extreme high has varied only about one foot.

In addition to precipitation and runoff, Lake Superior receives water by importation via the Long Lake-Ogoki hydroelectric projects located in Canada. This diversion averages nearly 5,000 cfs of water which formerly flowed north to Hudson's Bay. Because of the regulatory works at the "Soo" this diversion has not affected the level of Lake Superior.

There are over 100 streams in the three States which outlet to Lake Superior. Discharge information concerning the major streams is shown on Table 1. By far the largest stream tributary to Lake Superior is the interstate St. Louis River which enters the lake at Duluth-Superior. The lower St. Louis River has been extensively developed for production of hydroelectric power.

Most of the streams draining the north shore of Lake Superior are approximately 20 miles in length, characterized by a steep gradient and a high fluctuation in flow level. The one exception to this is the St. Louis River.

The Lake Superior drainage in the State of Wisconsin consists of a series of small streams flowing through the escarpment which exists around the south shore. Falls and rapids are characteristic along the escarpment line with some streams having hydro-power development. There are six hydroelectric power installations on the tributary streams.

There is a total of 78 streams in Michigan which outlet to the lake. The largest of these streams is the Ontonagon which has a drainage area of approximately 1,400 square miles.

There are approximately 2,000 lakes having areas of ten acres or more within the watershed. Most of the lakes occupy depressions in glacial deposits or are in ice block basins formed after the retreat of the glaciers. Approximately 600 of the lakes are in the north shore watershed area in Minnesota.

The ground water resources of the area bordering Lake Superior are quite variable. In many cases the glacial drift is too thin and discontinuous to provide adequate supplies of water. In portions of the basin, namely the St. Louis River watershed, there are extensive areas of unconsolidated sand and gravel which, in general, yield large quantities of water. In general, the quality of ground water is satisfactory for all uses.

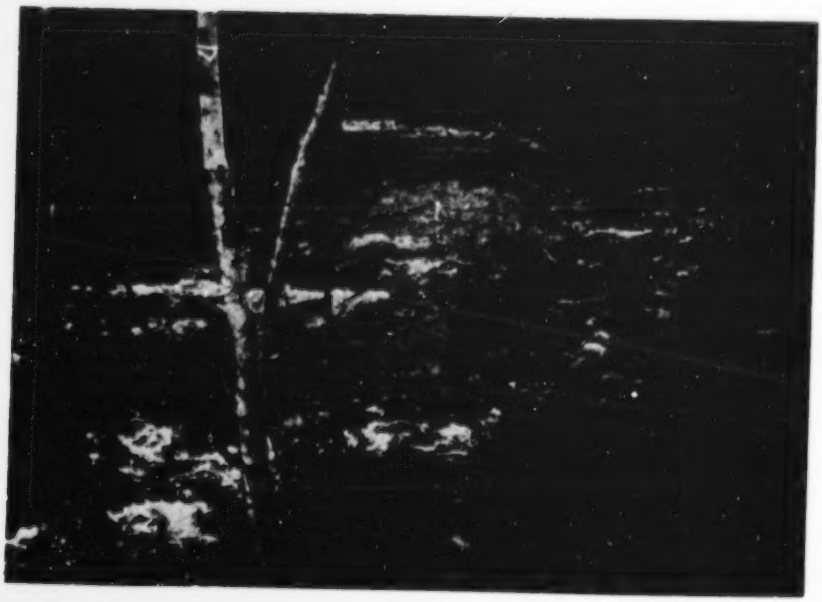
TABLE 1

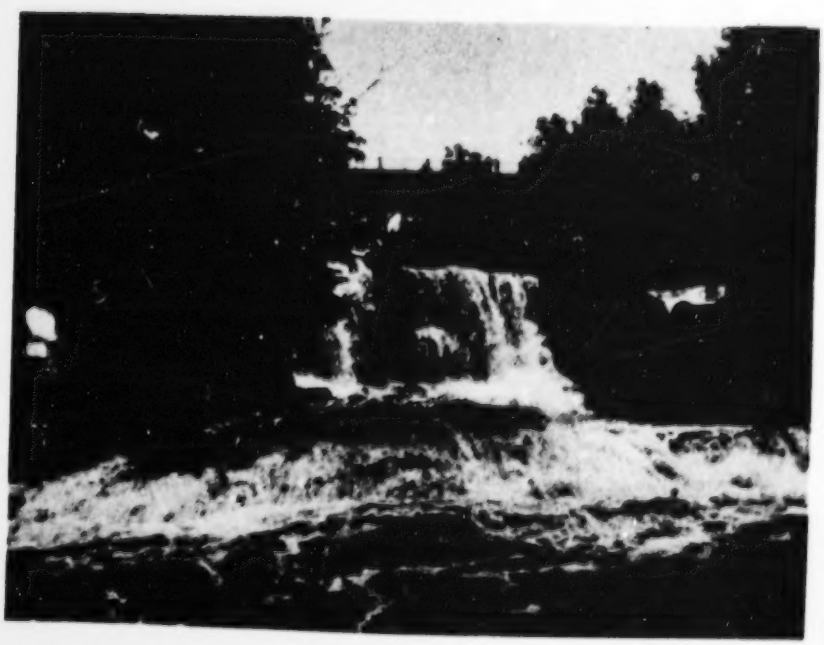
MAJOR UNITED STATES TRIBUTARIES TO LAKE SUPERIOR*

Name of River	Total Drainage Area (Sq. Mi.)	Gaged Drainage Area (Sq. Mi.)	Mean Discharge (cfs)	Period of Record (Water Yrs.)
Pigeon	610	600	483	1923-67
Brule	282	0	–	–
Baptism	146	140	159	1927-67
St. Louis	3,652	3,430	2,202	1908-67
Nemadji	446	0	–	–
Bois Brule	185	113	169	1942-67
Bad	1,016	611	605	1914-22 1948-67
Montreal	281	262	325	1938-67
Black	257	200	227	1954-67
Presque Isle	359	261	264	1945-66
Ontonagon	1,390	1,340	1,374	1942-66
Sturgeon	729	705	795	1942-66
Dead	166	0	–	–
Chocolay	161	0	–	–
Tahquamenon	820	790	849	1953-66
Waiska	147	0	–	–

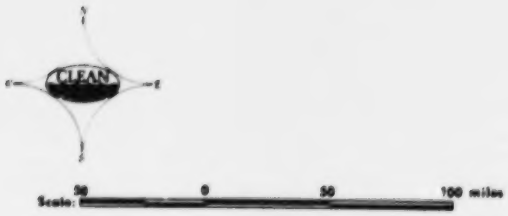
*Counterclockwise from U.S. (Minnesota) – Canadian Border

Data Source: USGS Surface Water Records of Minnesota and Wisconsin, 1967
USGS Surface Water Records of Michigan, 1966





Whitewater rapids and cascading falls are characteristic of Lake Superior's tributary streams.



NET SURFACE CIRCULATION OF LAKE SUPERIOR

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Synthesized current patterns

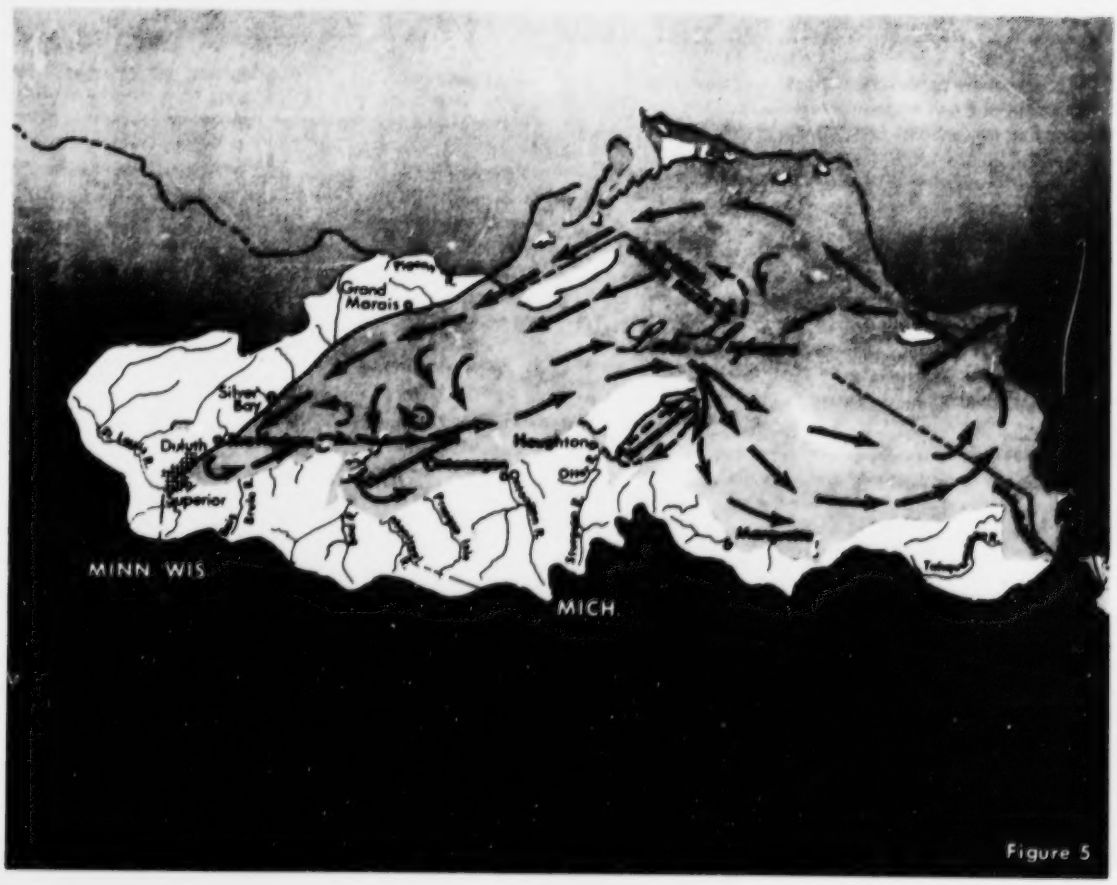


Figure 5

LAKE CURRENTS

Circulation studies of Lake Superior were begun in October 1966 by the FWPCA to determine the water circulation pattern of the lake, to establish the cause and effect relationships so as to be able to predict the movement of pollutants occurring in, and being discharged to the lake, and to develop a more accurate description and understanding of the physical, biological, and chemical phenomena of the lake.

To accomplish this, seven current-metering stations were emplaced in Lake Superior in October 1966. In May 1967 these meters were recovered and replaced and the current-metering network was expanded to a total of 17 stations. These stations were recovered in October 1967.

The current-meters were Richardson type, self-contained recording instruments, clock-activated periodically (every 30 minutes), recording directional and speed data for one minute on 16mm film then shutting off until the start of the next cycle. At each station current-meters were suspended at depths of 30, 50, 75 and 100 feet and every 100 feet thereafter. Temperature recorders were also installed at these depths.

The data from these stations were analyzed using accepted oceanographic techniques. What follows is a discussion of the findings.

Waterborne wastes reaching Lake Superior are dispersed into the main water mass by three means; molecular diffusion, turbulent mixing, and lake currents. Considering the lake as a whole, currents are the predominant mechanism for the movement and subsequent dispersion of these wastes into the lake's water mass.

While the inflow and outflow rate from Lake Superior is extremely small in comparison to the water mass of the lake proper, the lake water is not standing still. It is kept in constant motion principally by the wind which not only generates the visible surface waves but stirs and mixes the water throughout the lake.

Both water movements and rate of mixing are materially influenced by the formation of thermoclines, or zones of temperature transition between two layers of water which differ in temperature and density. In the summer, Lake Superior water becomes divided into an upper layer of warm readily circulating water, called the epilimnion, and a lower layer of cold, relatively undisturbed water called the hypolimnion. A region between these two layers where rapid temperature change takes place, is called the thermocline. When the lake water is thus stratified, the water in the hypolimnion (lower stratum) is essentially physically and chemically isolated from the remaining waters of the lake. In Lake Superior, nearly 95 percent of the lake's volume is in the hypolimnion. The summer stratification begins to develop in mid-June, with the epilimnion (upper stratum) reaching its maximum temperature in August. The thermocline is somewhat transient in Lake Superior in that it will move in and out of an area of the lake. When there is no thermocline, the water is isothermal (without a thermocline). In the winter months, the lake can be considered, for all practical purposes, to be isothermal and water mixing occurs throughout the lake.

Thermal bars, a phenomena resulting from a difference in temperature between adjacent waters along a vertical plane, occur in the spring and fall in shallow waters parallel to the shoreline. The fall thermal bar is not as extensive nor as well developed as is the one that occurs in the spring. A thermal bar inhibits mixing between the shallow waters along the shore and the deeper lake waters. Wastes discharged into the inshore side of the thermal bar tend to be held in the inshore area.

Because currents in the lake are motivated principally by the wind, and winds are variable, horizontal movement of the lake water exhibits an infinite variety and frequent changes in both direction and speed. A current change in less than six hours after a wind shift is common in mid-lake. The nearshore response may be even more rapid. However, certain recurring patterns have been identified, resulting principally from the fact that winds from one direction predominate.

The net circulation of Lake Superior is counter clockwise, with the possibility of large cyclonic eddies occurring in the western arm, or Duluth embayment, between Isle Royale and the Keweenaw Peninsula, and in the eastern basin. See Figure 5.

Superimposed on the net circulation pattern of the lake are other factors that affect water movement. The net circulations, while on a long-term basis may be considered the circulation pattern of the lake, exist for only short periods of time. One week would be considered a long period of time for the total net circulation pattern to exist.

Upwelling occurs in the lake when winds cause horizontal surface movement of water away from the shore. The surface waters are replaced by colder, deeper waters. Upwelling frequently occurs along the north shore during periods of northwest and west wind. Winds from the east and south produce upwelling along the south shore.

Other forces that affect water movement are internal waves, caused by storms and/or pressure differences acting on the lake's surface, and inertia currents resulting from decaying wind stresses.

In summary, while there is a net circulation pattern in the lake, a great many forces are acting which have a modifying effect upon water movements. These water movements are such that any persistent pollutant entering directly into Lake Superior or discharged into the water that feeds the lake, mixes with and becomes an integral part of the lake water as a whole.

There is a pleasure in the pathless woods,
There is a rapture on the lonely shore.

Lord Byron "Childe Harold"

WATER USES

The waters of Lake Superior are used for municipal and industrial water supply; recreation, including swimming, boating, fishing and other water oriented sports; commercial fishing; propagation of fish and aquatic life; commercial navigation; and esthetic enjoyment.

The waters of Lake Superior are of excellent quality for municipal water supply. Twenty-four municipalities and communities withdraw water from the lake for domestic usage. These systems serve approximately 184,000 people which use 25 million gallons per day (mgd). Communities in Michigan use approximately 5.7 mgd; Wisconsin approximately 1.3 mgd; and Minnesota approximately 18.0 mgd. The largest domestic supply is for the city of Duluth, which uses approximately 16 mgd, more than 60 percent of the total. Eight other communities in the basin utilize surface sources other than Lake Superior, withdrawing about 1.8 mgd. The remaining communities in the basin rely on ground water for their supply.

A twenty-three mile long water line is being constructed from Duluth to Cloquet, Minnesota to convey Lake Superior water to Cloquet for domestic and industrial water supplies. The pipe line will also serve the city of Superior, Wisconsin. The ultimate design capacity of the pipe line is 40 mgd. The initial capacity of the system will be 25 mgd. The scheduled completion date for the project is March 31, 1969.

An estimated 563 mgd of Lake Superior water is withdrawn for industrial purposes. Of this total 518 mgd are used by Minnesota industries, 42 mgd by Michigan industries and 3 mgd by Wisconsin industries. The largest single water user is the Reserve Mining Company taconite beneficiation plant at Silver Bay, Minnesota, which accounts for more than 90 percent of the total Lake Superior water used by industry. The use of industrial water on the tributaries of Lake Superior total approximately 200 mgd of which approximately 70 percent is used by the iron mining industries on the eastern end of the Mesabi Range in Minnesota.

Total electric power generation in the Lake Superior basin, including hydroelectric and steam generation, is estimated at about 850 megawatts. The largest hydro-power development in the basin is on the St. Louis River in Minnesota with a total installed capacity of 88,860 kilowatts. Steam power generation is estimated at approximately 650 megawatts, of which more than 60 percent is produced in Minnesota. A total of approximately 500 mgd of Lake Superior water is used for cooling purposes. Surface water other than Lake Superior used for cooling purposes totals approximately 130 mgd. There are at present no nuclear generating plants in the Lake Superior basin.

Records on commercial fish catches in Lake Superior have been kept since 1879. The catch averaged 7.8 million pounds from 1879 to 1908; 10.5 million pounds from 1913 to 1928; and 15.6 million pounds from 1929 to 1963. The catch reached a maximum of 22.1 million pounds in 1941 but since has declined to a 1967 level of 7.9 million pounds. The decline is related to biological and economical factors. In 1967 Lake Superior ranked third in commercial fish catches for the United States portion of the Great Lakes. Lake Michigan, 59.0 million pounds and Lake Erie 11.6 million pounds ranked first and second respectively.

There are relatively few fish species that constitute the bulk of the commercial catch in Lake Superior. Lake trout are undoubtedly the most popular and valuable fish. The maximum lake trout catch of 5.6 million pounds occurred in 1903. Between 1903 and 1955 the catch ranged between two and three million pounds, reaching 3.7 million pounds in 1944. The catch since 1955 has declined steadily, with the 1961 catch dropping to 323,000 pounds. From 1962 to the present lake trout fishing has been allowed under permit only. The chief cause of the decline of the lake trout was predation by the parasitic sea lamprey. Only drastic reduction of the sea lamprey population and intensive stocking by State and Federal agencies prevented total collapse of the lake trout fishery. A small amount of natural lake trout reproduction has now been found but the fishery at the present still depends upon stocking from hatchery raised fry. Indications are the population of lake trout in Lake Superior is increasing.

Drastic changes in the production of lake herring have occurred in the past twenty years. A maximum production of approximately 18 million pounds occurred in 1941 in United States waters, and declined to 10.8 million pounds in 1960. The abundance of herring has dropped significantly in the 1960's declining to 3.8 million pounds in 1967. White fish production, which typically fluctuates between 400,000 to 800,000 pounds, is currently about 500,000 pounds. A maximum catch of 1.3 million pounds was recorded in 1949. The smelt population, which at present produces a catch of 1.5 million pounds, is suspected as a causative factor in the decline of a number of native fish species. Chubs have been harvested to an increasing extent beginning in the late 1950's with production reaching 1.3 million pounds in 1959. The catch for 1967 was 1.9 million pounds. This fishery increased only out of economic necessity arising from the decline of lake trout.

The Lake Superior basin is an area of outstanding natural resources and great recreation potential. However, at the present only moderate demands are being placed on the basin's recreation resources. The relative inaccessibility of many recreation areas, because of their considerable distance from large population centers and a lack of better destination routes, in conjunction with a short tourist season are primary factors creating this situation. The current annual recreation demand is estimated at nearly 16 million recreation days. By the year 2000 this amount is expected to nearly double. Approximately 80 percent of the present demand can be attributed to vacation use.

In 1964 an estimated 1.4 million vacationists came to the Lake Superior basin for the primary purpose of outdoor recreation. The vacation sector comprises approximately 80 percent of the basin's total effective population. This approximation does include a few basin residents but by far the greater number are non-residents.

While the list of recreation activities available in the basin is quite endless, the vast majority of recreation activities in the basin are centered around or near water. These include boating, fishing and those activities significantly enhanced by the presence of water such as hiking, camping, sight-seeing and driving for pleasure.

Pleasure boating is rapidly increasing in the Lake Superior basin.

The United States Bureau of Outdoor Recreation report, "Water Oriented Outdoor Recreation - Lake Superior Basin" (44), presents a detailed discussion of recreation in the basin including information on existing facilities, the problems that are developing, and the action that must be taken to preserve this natural heritage.

Even though it is recognized that recreationists participate in all the other basic activities in addition to sight-seeing, it is the attraction of this latter activity which draws most recreationists to the basin. Probably Lake Superior's greatest asset is its scenic shoreline.

Water quality is a most important factor influencing the recreational uses which are made of the water, as it affects the quality of the outdoor recreation experience. Water oriented recreational activities may be divided into two categories -- one of which involves actual contact with the water. This category is further broken down into activities involving the whole body contact such as swimming and water skiing and those involving limited contact such as pleasure boating and fishing. The other category involves the esthetic enjoyment of viewing the body of water and its surroundings. This includes such activities as driving and hiking for pleasure along the shore of the body of the water. An important part of the recreational value of water is its esthetic aspect. Camping, picnicking, sight-seeing, while not directly water oriented activities, are considerably enhanced as an experience by esthetically pleasing water. Some pollution robs the water of its esthetic value for such activities.

The severity of a pollution problem can vary from place to place on a given body of water and in many instances from time to time depending on weather and other factors. In addition, people vary widely in their opinions as to the point at which water quality has deteriorated to the extent that it is no longer suited for a certain recreational activity.

Therefore, it can be seen that water quality per se has a demonstrable effect on recreational use. Many of the factors which contribute to the degradation of water quality can be measured readily; for example, rise in water temperature due to thermal pollution and amount of silt added to a stream as a result of land runoff. However, sociological factors which are very difficult to measure, play a key role in determining the extent to which quality will influence recreational use. These latter factors become very personal and differ with the individual depending upon his education and environmental background.

Numerous State and Federal lands in the Lake Superior basin offer recreational opportunities that can be enjoyed by all.

III. THE POLLUTION PROBLEM

Lakes may be classified according to their level of primary productivity. The productivity or "fertility" of a lake depends on nutrients received from regional drainage, on the depth, plus other interrelated factors which affect the metabolism of the lake. A eutrophic lake is at one end of the classification series and on the other end is an oligotrophic lake. While there are a number of characteristics associated with oligotropic lakes, in short they are still "biologically young" and have changed little since the time of their formation.

Lake Superior is an excellent example of an oligotrophic lake having very clear, cold water and very few living organisms. The lake is an exceedingly young lake in terms of its biological aging processes. It is thousands of years behind the other Great Lakes considering only natural ageing. The lake nearly resembles its pristine condition as created eons ago.

Lake Superior has been the least studied of all the Great Lakes. Most of the studies conducted have been in the western portion of the lake. There are very little data for the lake during the winter season and essentially nothing is known about bottom organisms, bottom character, and fish species in the deeper portions of the middle of the lake.

Lake Superior is a delicate lake and therefore great caution must be exercised when weighing the potential dangers to its ecology. Increases normally considered insignificant or acceptable in most lakes will dramatically alter this lake, because even such small changes will represent a large percentage of change. For example, an increase in 5 units in turbidity will result in a reduction of many feet in light penetration and significant loss of fish food organisms. The very cold temperatures keep production of phytoplankton at a very low level. The growth of algae in the lake can be loosely compared to algal growth that would occur in a beaker of water placed in a lighted refrigerator.

It is also true that a slight reduction in the food producing capacity of the lake is likely to evidence itself in lower fish production because food appears to be limiting in the lake. Shallow shore areas, one of the major fish food producing areas in the lake, are limited and therefore are extremely important to the survival of the fish species of the lake. These are the same areas first to be affected by man-made waste discharges. Because algae productivity is low, the depth to which light penetrates is important for producing sufficient plankton, periphyton and benthos in the shore areas.

The native fish species in Lake Superior such as lake trout have long egg incubation periods; some of them reaching two to three months. Conditions must be ideal during this critical period to enable the eggs to hatch. Because the eggs are deposited on the lake bottom, small quantities of silt or settleable solids are likely to smother the eggs as they are left unattended by the adult fish.

The addition of certain kinds of toxic materials into Lake Superior is of prime importance. The heavy metals (i.e., copper, iron, zinc, etc.) are highly toxic at low concentrations because the water is soft, the fish species found in the lake are sensitive to metals and because the metals are persistent and will remain in the lake for longer periods of time due to the lake's slow flushing rate. Many of the common metals found in the surface waters could seriously affect the reproductive potentials of the fish species in Lake Superior at concentrations in the range of 2 to 50 parts per billion.

The quality of Lake Superior water is so high compared to other lakes that the early signs of damage may go undetected or may be excused as being insignificant. Using standards of clean water normally considered appropriate in pollution control programs, Lake Superior could be degraded considerably and changed significantly before water uses would be damaged.

Pollution problems have occurred in the Lake Superior basin. Some of the existing problems, both in the lake and on the interstate tributaries are discussed in the following sections.

CHEMICAL POLLUTION

Pollution by dissolved chemicals covers a broad range of substances including heavy metals such as copper, iron and zinc, phenolic compounds, oil, nitrogenous materials, phosphorus, chlorides, and colored waters. Two general types of effects are produced by such chemicals: (1) local and immediate effects in the vicinity of the source, and (2) a progressive buildup in the concentrations of certain persistent chemicals in the lake as a whole. Concerning the latter effect, great caution must be exercised in order to avoid long-term damage in Lake Superior as the self-purging rate has been estimated to be well in excess of 500 years (45). In addition, eddy currents that may occur in the western end of the lake tend to limit the intermixing of these waters with the rest of the lake.

Lake Superior and Lake Michigan are the headwaters of the Great Lakes as their outflow passes through Lakes Huron, Erie and Ontario. Constituents dissolved in Lake Superior waters such as nutrients which tend to accumulate in a lake could therefore add to the accumulated levels in these downstream lakes. While the effects of these dissolved constituents may not be felt in Lake Superior due to other limiting factors, conditions may be suitable in the downstream lakes to result in a degraded water quality.

The heavy metals, as a group, are especially important in Lake Superior for several reasons. Because there is a low mineral concentration in the lake, metals are more toxic than they would be in average waters in the United States. In addition, several important species of fish, especially lake trout, whitefish, and lake herring, are unusually sensitive to such metals as copper, zinc and chromium. Natural agents are lacking in the lake to bind such metals and render them inactive.

An industrial waste discharge to a tributary stream in Wisconsin causes a discoloration of Lake Superior waters.

Heavy metals are reaching Lake Superior through natural erosion of the mineral laden rock in the drainage basin and as a result of mining activities. Amplification of aspects related to mining activities is found in another section of this report.

Very important chemical constituents in a lake are the levels of nitrogen and phosphorus. Aquatic vegetation including algae are capable, through photosynthesis, of utilizing inorganic elements in support of growth -- including nitrogen and phosphorus. These nutrients have been given the most attention because following carbon, they are required in the greatest amounts for the production of green plants. Bodies of water receive these nutrients from many sources such as natural runoff from agricultural and urban land, ground water, precipitation and sewage and industrial waste effluents.

Information available shows that in Lake Superior, overgrowth of algae is not a problem. The low temperature of the water is very likely a limiting factor in the lake's productivity. The harbor areas and inshore lake water near the harbors are most susceptible to nuisance aquatic vegetation growths because they are more easily affected by man's activities and because other conditions, such as higher water temperatures and phosphorus concentrations necessary for nuisance conditions, more frequently occur.

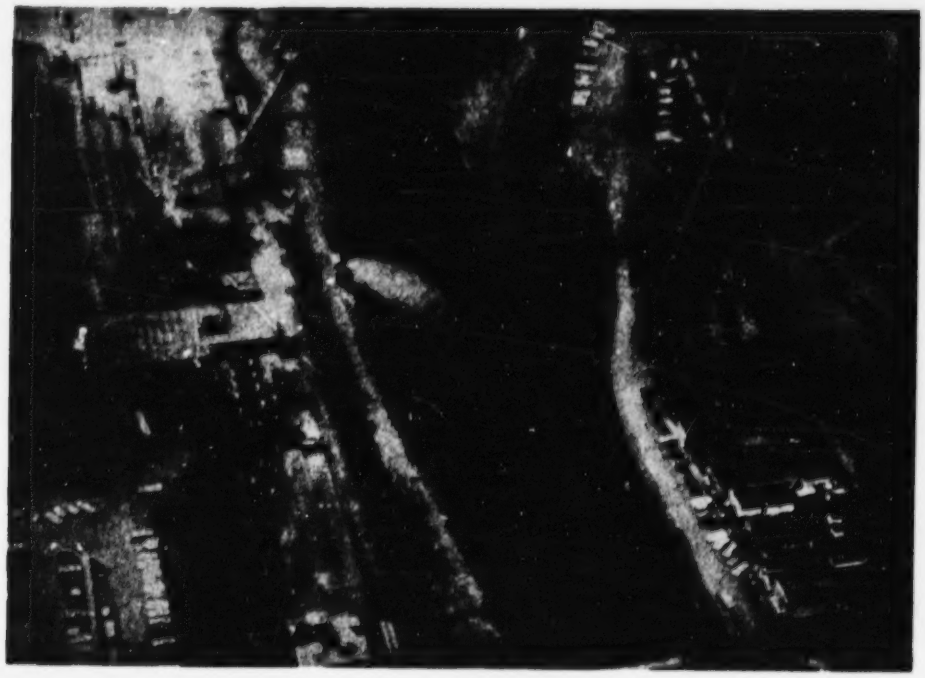
The three States in the basin have included statements on phosphorus removal in their interstate water quality standards. In addition, the Michigan Water Resources Commission adopted a resolution in October 1967, which calls for the removal by June 1, 1977 of phosphorus compounds from wastes discharged to the waters of the State. Minnesota has adopted statewide effluent standards which require the removal of phosphorus from waste discharges to certain lakes and reservoirs. The cities of Duluth, Two Harbors, and Grand Marais have been required to install phosphorus removal facilities by 1971; Silver Bay by 1972.

OXYGEN DEPLETION

Dissolved oxygen (oxygen held in solution in water) provides the basic respiratory supply for most living organisms, including not only fish but also the bacteria which consume organic matter. Therefore, dissolved oxygen is a most important ingredient necessary for a healthy, balanced aquatic life environment. Decomposable organic matter can cause an excessive reduction of the dissolved oxygen concentrations in the water because oxygen is consumed by the respiration processes of some living organisms. The oxygen is replenished by absorption from the atmosphere and through the photosynthetic processes of aquatic plants provided a well balanced environment exists. Organic pollution alters the environmental balance. The bacteria in the water or introduced with the waste, utilize the organic matter as food, multiply rapidly and reduce the dissolved oxygen. The resulting oxygen deficiency may be great enough to inhibit or destroy fish and other desirable organisms, and result in taste and odor problems. Excessive depletion of the dissolved oxygen results in the generation of many nuisance conditions.

At the present time the main body of Lake Superior has not shown any signs of oxygen deficiency. (13, 22, 31, 32, 35) This coincides with the characteristic of an oligotrophic lake in that there is ample oxygen at all water levels within the lake. In this case, the oxygen levels are at or near the saturation point at all depths.

Oxygen depletion is occurring in some of the tributaries draining into Lake Superior. In the Minnesota drainage, reaches of the lower St. Louis River from Cloquet to the Duluth - Superior harbor have on numerous occasions been excessively depleted of oxygen. (38, 55) Inadequately treated sewage effluent and inadequately treated industrial wastes discharged into this reach have been the source of the problem. The condition is aggravated by the operation of the hydroelectric plants on the river which cause wide fluctuations in river flow.



Industrial waste discharges to the lower St. Louis River have caused serious pollution problems.

Sources of waste in the Duluth - Superior harbor have also created localized areas of substantial oxygen depletion. Sources of pollution include inadequately treated municipal wastes plus inadequately treated industrial wastes from various points.

The interstate Montreal River downstream from Hurley, Wisconsin and Ironwood, Michigan has experienced oxygen depletion problems. (12) The proportion of the oxygen depletion caused by the waste discharges from each of these two cities has not been determined.

Under the provisions of interstate water quality standards, the State regulatory agencies have initiated actions to eliminate the oxygen depletion problems occurring on the tributary streams.

BACTERIAL POLLUTION

The presence of coliform organisms in water is considered an indicator of degraded water quality and a possible indicator of a health hazard. Coliform organisms are significant because they occur in the fecal matter of all warm-blooded animals, including man. Consequently, the presence of these bacteria in a body of water is considered evidence of fecal contamination. Since such contamination is one avenue of transmission of certain waterborne disease, the presence of coliforms is also an indication of a health hazard from accompanying pathogenic bacteria and viruses.

The largest coliform concentrations in water are usually produced by human contamination, but elevated counts will also occur after rainfalls due to land runoff and/or storm and combined sewer overflows. Pathogenic bacteria from human sources can be adequately controlled by proper treatment and disinfection of waste discharges.

The bacterial quality of the main body of Lake Superior is excellent. The problems of bacterial contamination that have occurred were found along certain tributaries and some harbor or inshore areas around the lake. Instances of impairment of water use in the basin by bacterial pollution have been documented by the Bureau of Outdoor Recreation. (44) Some of the areas that have experienced bacterial pollution are portions of the St. Louis River and Duluth Harbor area in Minnesota; and Superior Harbor area, Ashland inshore area and reaches of the Montreal River in Wisconsin.

Some cities in the basin are served by combined sewer systems so that quantities of a mixture of storm water and sewage are discharged without treatment during and after every heavy rain. This has resulted in bacterial pollution of some reaches of rivers in the basin. Bacterial pollution in most cases is amenable to correction. This is the case wherever the waste can be put through a treatment plant followed by disinfection.

The State regulatory agencies have taken actions to eliminate existing bacterial pollution problems and to prevent future undesirable conditions. The States of Michigan and Wisconsin require year around disinfection of waste treatment plant effluent. Minnesota requires year around disinfection at all waste treatment plants in proximity to water supply intakes and seasonal disinfection of effluents discharged to waters used for recreation. In addition, all three States have required separation of combined sewers or other remedial action to prevent pollution from this source.

MINING ACTIVITIES

There are 151 active mineral operations within the Lake Superior basin. Table 2 shows the distribution by State and mineral commodity of these operations. Not all of these operations are "wet" industries, i.e., utilize quantities of water in their processes. The waste disposal practices followed by the "wet" operations are shown in Appendix A.

There have been water quality problems associated with mining operations in the basin. Wastewater originates from open pit iron ore mining as a result of the entrance of rainwater and seepage into the mines. The water must be pumped out to maintain a dry area for mining operations. The quantity of water may range from almost nothing to several thousand gallons per minute. This water may be highly colored and very turbid or may be crystal clear, depending upon the type of ore body and manner of collection.

Ordinarily pit water which is pumped from the bottom of an open iron ore pit is extremely turbid, has a bright red color, and may have a very high suspended solids content. The term "red-water" is frequently applied to this and similar wastes for obvious reasons. The occurrence of red-water resulting from natural drainage is also quite common in the streams near ore dumps.

The discharge of water or drainage containing large quantities of suspended material into surface waters may create unfavorable conditions for fish and wildlife. It also may affect the use of recreational areas, and stream shore property. If large amounts of suspended materials settle out in shallow areas, fish spawning beds may be covered and the penetration of light so reduced as to have an adverse effect on the growth of aquatic plant and animal life. The red color of the material in the water from mining areas emphasizes the presence of suspended material which tags the waters in the area.

Although periodic problems do arise as a result of red-water, control measures by the State regulatory agencies have proved to be effective in combating this problem.

TABLE 2

ACTIVE MINERAL OPERATIONS IN LAKE SUPERIOR BASIN

MINERAL COMMODITY	MICHIGAN	MINNESOTA	WISCONSIN
Iron Ore	9	27	
Copper	7		
Sand & Gravel	32	50	10
Iron & Steel		1	
Cement		1	
Clay		1	
Granite			2
Lime		1	1
Peat		4	
Stone	4	1	
Total	52	86	13

Reserve Mining Company's E.W. Davis taconite beneficiation plant at Silver Bay. Light areas are tailings being carried by a stream of water a few inches deep over the solid delta beach to the lake.

Active underground mines must continually be drained and previously abandoned shafts that are being reopened to development must be drained to allow full operation. This water is characteristically quite high in total dissolved solids such as chlorides and sulphates. Depending upon the nature of the underground strata, heavy metals such as copper, iron and zinc will be leached from the soil and be contained in this discharge water. As stated previously in this report, the discharge of heavy metals to the waters of Lake Superior is of concern due to the extreme sensitivity of aquatic life in the lake to these metals and due to the long-term buildup of these metals in the lake. A quantification of the past practices of draining mines is not available. Care should be exercised in the future to prevent the adverse effects on aquatic life in the receiving streams and also to Lake Superior from such drainage practices.

With the development of the taconite beneficiation process, vast new areas were opened up to the mining of taconite ore. As can be seen by Table 2, there are 36 mineral operations related to taconite processing in the basin including 15 concentrator plants. As shown in Appendix A, 14 of these utilize a closed system whereby their wastewater is allowed to settle in a lagoon and the waters recirculated for use. One of these concentrator plants, Reserve Mining Company, E. W. Davis Works, discharges its wastes directly to Lake Superior. The operations of this plant are discussed below.

Reserve Mining Company, E.W. Davis Works

In response to a request from the U.S. Army Corps of Engineers for comments on revalidation of the Corps' permit to Reserve Mining Company, several agencies of the U.S. Department of the Interior and other units of government reported continuing concern over the deposition of taconite tailings into Lake Superior. In response to these concerns an Interior study group was formed to investigate the effects of the taconite tailings on Lake Superior. Participating Department of the Interior agencies in the Taconite Study Group were Regional Coordinator, Office of the Secretary, Chairman; Bureau of Sport Fisheries and Wildlife; Bureau of Commercial Fisheries; Bureau of Mines; Geological Survey; and FWPCA. The U.S. Army Corps of Engineers, Minnesota Department of Conservation, Minnesota Pollution Control Agency, and Wisconsin Department of Natural Resources provided information to the study group and acted as observers in the group's activities.

Based on data gathered by the individual agencies comprising the Taconite Study Group (49, 50, 51, 52, 53) and other State reports following conclusions were reached:

1. Approximately 45 percent of the tailings waste discharged between 1956 and 1967 were deposited on the delta off shore from the plant. The remaining 55 percent, or approximately 95 million tons, traveled down the face of the delta into the lake. Tailings are deposited on the lake bottom at least 10 miles off shore and 15 miles southwest of the plant.

2. Approximately 60,000 long tons of taconite waste are discharged daily from the plant. Fifty-four hundred long tons per day of the waste solids discharged to Lake Superior are less than 4 microns (1 micron equals 1/25,400th of an inch) in diameter. Particles of this diameter are capable of remaining suspended in water for a considerable time after discharge.

3. Current measurements in the vicinity of Silver Bay show that the prevailing current is to the southwest and of sufficient velocity to transport particles of 4 microns or less more than nine miles per day.

4. As the tailings meet Lake Superior water, "billowy gray clouds" of waste were visible leaving the density current, both at and under the water surface near the shore line. Extending off shore as far as 300 feet, these clouds were observed and photographed at at a depth of 35 feet. It appeared that "green water" was formed as gray tailings clouds diffused (became less concentrated) and more daylight penetrated among the particles.

5. The occurrence of tailings was evident in "green water" masses. In one instance the "green water" containing tailings was visibly present 18 miles southwest from the plant. "Green water" was observed along the Wisconsin shore line and did not contain tailings.

6. "Green water" containing tailings has a measurably increased turbidity and contains at least two to three times more suspended solids than does water that appears clear to the eye.

7. The State of Minnesota report (54) reported a reduction in the abundance of fish food organisms associated with the deposition of taconite tailings on the bottom of Lake Superior. It was estimated the reduction in fish food organisms could be expected to result in a reduction of the total annual fish catch (commercial and estimated sport fishing) of 5 percent or less for the area having tailings on the bottom.

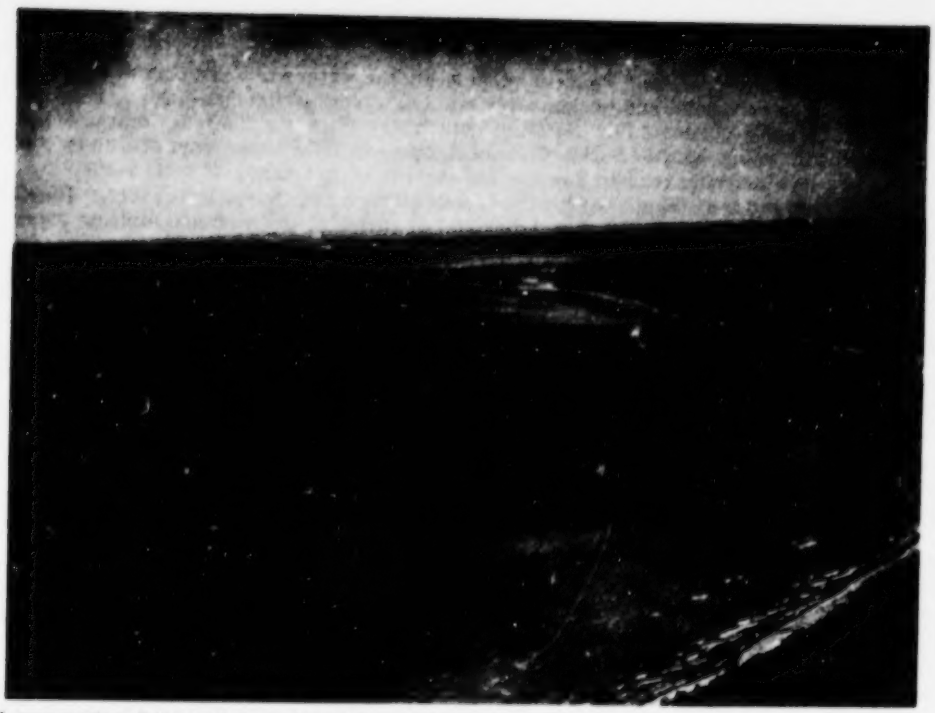
8. The study area selected (nine miles by five miles) for sampling was too small to define the full extent of the area adversely affected. Analysis of data by the Study Group indicates that the area affected extended beyond the furthest sampling point.

9. High concentrations (10 percent and 25 percent) of taconite wastes caused mortalities among sac fry of rainbow trout in 4-day exposure. The wastes were not acutely toxic to fingerling sized coho salmon, rainbow trout, white suckers, black bullheads, blue gills, and yellow perch in 96-hour, static bioassays.

10. Chemical analysis projected to the probable daily discharge shows the following discharge, measured in pounds of certain parameters: copper, 4,100; nickel, 2,500; zinc, 2,500; lead, 6,100; chromium, 6,200; phosphorus, 51,500; and manganese, 629,000. Other elements in the discharge include silica, arsenic, and substantial quantities of iron. The chemical state of these metals was not assessed and it would be presumptuous to say at this time what portion of the elements enter into solution.

11. A distinguishing characteristic of tailings discharged by the Reserve Mining Company is the presence of large quantities of the amphibole cummingtonite.

Data gathered by the FWPCA since April 1, 1969 has shown the presence of taconite tailings, (utilizing cummingtonite as a tracer) in the municipal water systems of Beaver Bay, Two Harbors, and Duluth, Minnesota. There has not been sufficient time to determine what effects, if any, the presence of the tailings has on the quality of the water supply or the users thereof.



A large portion of the south shore of Lake Superior is discolored by the sediment contained in discharges from streams draining the red clay area of northwestern Wisconsin.

SOIL EROSION

Tributary streams to Lake Superior discharge many tons of sediment annually to the lake. The sediment is derived from the natural processes of weathering and erosion of the rock and soil and by the activities of man in the basin, and is transported to the lake by the surface streams. The sediment yield is low when compared to the yields in other areas of the country. The estimated average annual yield of north shore streams tributary to Lake Superior is 10 tons per square mile. The low yield is due to the geology, soil types, vegetation and land uses in the basin.

An exception to the generally low sediment yields of Lake Superior tributaries are the streams along the south shore of the lake in the northwestern red clay area of Wisconsin. This area, containing 880,000 acres of land in Ashland, Bayfield, Douglas and Iron Counties is the most severely eroded and high sediment producing area in the basin. Limited data on the Bad River near Odanah indicates a long term average sediment yield of 278 tons per square mile.

Damage to valuable trout and recreational streams by sediment resulting from erosion of the red clay area has occurred. A large portion of the south shore of Lake Superior is discolored by the sediment contained in the discharges from these streams. This adversely affects the aquatic life in the lake by reducing the depth of light penetration and in settling on the lake bottom.

These problems have been recognized by interested Federal, State, and local agencies and are currently under investigation. The Red Clay Interagency Committee, comprised of Federal, State, and local representatives, issued a report in 1967 which identified the sources and causes of erosion and sedimentation and proposed an action plan for corrective measures. (28)

WASTES FROM WATERCRAFT

Commercial, recreational, and Federal vessels ply the waters of Lake Superior and are contributors of both untreated and inadequately treated wastes in the open lake and in the harbor areas. A study conducted by the Minnesota Water Pollution Control Commission (predecessor of the Minnesota Pollution Control Agency) in 1965 of the Port of Duluth concluded that raw and partially treated sewage and significant quantities of solid refuse and grease are discharged into Duluth harbor from both foreign and domestic vessels. They also concluded that facilities for collection and disposal of garbage, dunnage and similar refuse from foreign vessels exists at the port but are too small to serve all the shipping entering the port. As a result, domestic vessels and possibly a few foreign vessels dump this accumulated material overboard while out on Lake Superior and the other Great Lakes. The report recommended a vigorous program to control the disposal of all types of wastes from watercraft in the port. The report also recommended that the facilities for collecting the wastes be expanded and collection and disposal of solid refuse from all vessels both domestic and foreign be required.

Certain aspects of water pollution from watercraft have been documented in the report "Wastes from Watercraft" (48). This report principally considered pollution caused by the discharge of sewage, bilge and ballast waters, compartment washings, and litter. The report points out that the problem of pollution from watercraft is both widespread and varied; widespread because vessels and boats frequent all navigable water areas of the Nation and may trigger local pollution at any point along their path; varied because of the assortment of materials which may be spilled or discharged from vessels. A proposed program for the control of pollution from vessels set forth in the report covers four major waste categories: (1) sewage; (2) bilge and ballast waters; (3) litter and related solids; and (4) oil.

Item 10 of the Summary of Findings contained in the "Wastes from Watercraft" report states: "Federal laws and regulations prohibiting the dumping of litter, sewage, and wastewaters in specific locations are intended primarily to prevent impairment of navigation and the spread of communicable disease, animal diseases and plant pests. They are not now wholly effective in preventing water pollution." Bills have been introduced into the 91st Congress to control wastes from watercraft.

The States of Minnesota, Wisconsin and Michigan have laws dealing with the vessel pollution problem. Minnesota's law is applicable to pleasure craft registered in the State and permits the use of marine toilets equipped with a suitable treatment device approved by the Minnesota Pollution Control Agency. Registration is contingent upon certification that watercraft with marine toilets are equipped with an acceptable device. Types of devices accepted include macerator/chlorinators, holding tanks and incinerators. The State prohibits the discharge of other wastes and the abandonment of containers holding sewage or other wastes which may create a nuisance, health hazard, or water pollution. All waters of the State are included in the law.

The Wisconsin law applies to the inland waters of the State and, therefore, by definition does not apply to Lake Superior. On applicable waters the law requires the use of a holding tank on any boat which is equipped with a toilet that is not sealed. Chemical type toilets and incinerator type toilets may also be used provided the material cannot be disposed of into the water and that the toilet is of sufficient capacity to handle the passenger load. Wisconsin has prepared a similar bill for introduction into the current session of the Legislature that would apply to all waters within the jurisdiction of the State, which would include Lake Superior.

Michigan laws are specific in prohibiting garbage, oil, and refuse dumping from watercraft 25 feet or more in length. Also, the disposal of such wastes from smaller watercraft and the disposal of wastes from marine toilets could be prosecuted under the State's general health laws. The Michigan Water Resources Commission in January 1968 adopted a rule to control pollution from marine toilets on watercraft. The rule does not allow the macerator/chlorinator and does authorize the use of holding tanks or incinerators. The rule becomes effective January 1, 1970.

OIL POLLUTION

People throughout the world became aware of the destructive characteristics of oil spilled in the water environment, and the inadequacy of current measures for dealing with a major spill when the Torrey Canyon ran aground and broke up off the coast of England in March 1967. On May 26, 1967 the President of the United States directed the Secretaries of the Interior and Transportation to undertake a joint study to determine how the resources of the Nation could best be mobilized to counteract the pollutional effects of spills of oil and other hazardous materials in our waterways. One of the major needs disclosed by the study was for the development of a contingency plan to deal with emergencies involving Federal, State, and local agencies with due regard for each agency's statutory responsibility and capability. On June 7, 1968 the President directed the Secretaries of the Interior, Defense, and Transportation and the Director of the Office of Science and Technology to assume special responsibilities in strengthening our preparedness to act in the event of a major oil spill. The Secretary of the Interior was directed to assume primary responsibility for completing by July 31, 1968, a draft of a national multi-agency contingency plan for responding to major pollutional spills. The National Plan was approved by the President on November 13, 1968. The National Plan provides guidelines for the establishment of regional contingency plans. Regional Offices of the Federal Water Pollution Control Administration have developed framework regional contingency plans and are now expanding these plans in accordance with provisions of the National Plan.

Although oil pollution is presently not a significant problem in Lake Superior, steps have been taken to insure that a coordinated response of effort among Federal, State, and local agencies will occur in the event of a major spill. A Contingency Plan for Lake Superior has been developed in accordance with provisions of the National Plan by the Great Lakes Region of the FWPCA. The purpose of this Plan is to present guidelines to minimize the pollutional effects of a major spill of oil, or other hazardous materials in Lake Superior. The objectives of this plan are to develop effective systems for discovering and reporting the existence of a pollution incident, promptly instituting measures to restrict the further spread of the pollutant, application of techniques to clean up and dispose of the collected pollutants, and institution of action to recover cleanup costs and effect enforcement of existing statutes.

Major legal capabilities available to the United States to control oil pollution include the Federal Water Pollution Control Act as amended, the Oil Pollution Act of 1924 as amended, and the River and Harbor Act of 1899.

DISPOSAL OF DREDGED MATERIAL

Responsibility for the improvement and maintenance of the waterways of the United States in the interest of navigation has been delegated by acts of Congress to the U. S. Army Corps of Engineers. In carrying out this responsibility, the Corps dredges approximately 10 million cubic yards annually from Great Lakes harbors and in calendar year 1968 dredged about one million cubic yards from harbors on Lake Superior. Two-thirds of this total represented deepening of a portion of Duluth - Superior harbor. The normal annual maintenance dredging program in Lake Superior is around 300,000 cubic yards. This is conducted in some of the commercial harbors shown in Figure 4, and in small boat harbors maintained by the U. S. Army Corps of Engineers.

The Corps has followed the practice of disposing of most dredged material in authorized dumping grounds in the open waters of the Great Lakes. Dredging of areas outside the authorized navigation channels, in the vicinity of the docks, loading facilities, marinas, etc., is accomplished by private interests under permit from the Corps. The dredged material ranges from clean lake sand to river sediments which may be seriously polluted by industrial and municipal wastes. The dredgings may contain oil and grease, dissolved solids, nutrients and toxic materials.

Attention has been directed to the problem of the disposal of polluted dredged materials by the Great Lakes Region, FWPCA. The FWPCA is concerned about the long-term cumulative effect on incremental additions of these pollutants to the Great Lakes.

During the past two years the Corps of Engineers and Federal Water Pollution Control Administration have been carrying out a joint study of the water quality problems associated with dredging. A report of findings is now available for perusal at the Corps District Offices and various other locations. In the meanwhile, the Corps has provided alternate disposal of materials dredged from several of the most polluted harbors on the Great Lakes. No harbors in Lake Superior are included in this pilot program.

Results of sediment analysis by the FWPCA in Lake Superior harbors indicate the presence of polluted materials in certain areas of Duluth - Superior, and Ashland harbors. The analysis showed the sediment contained unacceptable levels of oil and grease, phosphorus and chemical oxygen demand. The FWPCA will continue to assist the Corps of Engineers by classifying harbor sediments as to their suitability for open lake disposal. The Corps should continue their program of developing alternate disposal areas for polluted sediments.

PESTICIDES

In general, the problems associated with pesticides are problems involving biological magnification of the pesticides in food chains or human food. Furthermore, there is not enough information at this time to understand or even estimate the importance of a given concentration of an insecticide such as DDT in the water or the bottom sediments. Based on these reasons, the concentration of insecticides in fish tissues is one of the best ways of monitoring the contamination of pesticides in a lake.

The word insecticide will be used henceforth in this report because no information is available to suggest that any significant amount of pesticides, other than insecticides has been detected in Lake Superior.

Information necessary to determine the kinds and quantities of insecticides used in the Lake Superior basin was not available. Some data on the concentration in fish were found. Concentrations of insecticides are lower in the fishes of Lake Superior than in the fishes of any other of the Great Lakes according to data furnished by the Bureau of Commercial Fisheries. Compared to similar species from Lake Michigan these fishes have from four to seven times less DDT and two to seven times less dieldrin. The absence of a Dutch Elm disease problem, very little industry, and little farming, probably account for the low values reported. The persistent insecticides, such as the chlorinated hydrocarbons must be kept from entering Lake Superior. If they do accumulate there, damage will be apparent for a long period of time due to the slow flow-through time of the lake. Since the harvested organisms, fish, comprise a larger percentage of the lake's biomass than in the other Great Lakes, less insecticide need be added before unacceptable amounts will occur in the important fishes. This is especially important since the most important species, lake trout, is a long-lived, predatory species and therefore is an efficient accumulator of insecticides. The low organic matter content of the water and sediment will also favor accumulation of insecticides in fishes.

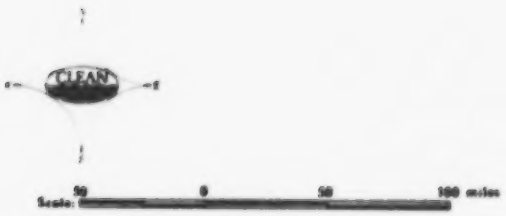
Studies made by the Bureau of Commercial Fisheries indicate that dieldrin presently poses no problem in Lake Superior. Dieldrin levels are little above usual detection limits. One important reason may be that little or no corn is grown in the basin and so the commonly used insecticide for corn, aldrin (that converts to dieldrin) in not extensively used.

DDT (including DDT, DDD and DDE) is also much lower in Lake Superior than in the other Great Lakes but in several species, chubs, lake herring, and larger lake trout, the concentrations are approaching 1.0 microgram per gram, or above, of wet weight of fish.

As part of the Lake Michigan enforcement conference, a Technical Committee on Pesticides was established to evaluate the pesticide problem in Lake Michigan and to recommend to the conferees a program of monitoring and control. The Committee determined that controls should be instituted to insure that the concentration of various insecticides did not increase above existing levels in Lake Superior as there are no indications of problems in Lake Superior fish resulting from these levels. The recommended levels by that Committee therefore were that the concentration of DDT in fish not exceed 1.0 microgram per gram; DDD not exceed 0.5 microgram per gram; dieldrin not exceed 0.1 microgram per gram and all other chlorinated hydrocarbon insecticides, singly or combined, should not exceed 0.1 micorgram per gram. Limits apply to both muscle and whole body and are expressed on the basis of wet weight of tissue (56).

The Food and Drug Administration officially informed that same Committee that concentrations of 0.3 parts per million of several insecticides, including dieldrin, in the edible portion of a fish would be considered sufficient to warrant legal actions.

Indications are that uses of pesticides in the Lake Superior basin are at relatively low levels. Even with a low usage, insecticides are being concentrated in fish and underline the importance of caution and surveillance to avoid a future problem.



MAJOR INTERSTATE WATERS

LEGEND:
Interstate waters

Figure 6

IV. POLLUTION CONTROL ACTIONS AND PROPOSALS

The necessary pollution control actions needed to prevent, control, and abate water pollution depend upon close cooperation with Federal, State, and local units of government. By working together and applying their respective capabilities the needed pollution control actions come into fruition. While the Federal role in water pollution control has become a very significant one, the basic Federal law recognizes the primary right and responsibility of the State agencies for the necessary pollution control actions in any State. Some of the actions taken by the State to abate pollution have been discussed in previous sections of this report. This section presents the Federal Water Pollution Control Administration program plus additional aspects of the State programs.

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION ACTIVITIES

The responsibilities of the Federal Water Pollution Control Administration were set forth by the Congress in the Federal Water Pollution Control Act passed in 1956 and subsequently amended in 1961, 1965 and 1966. The FWPCA, through the Great Lakes Regional Office, is pursuing a vigorous water pollution control program in the Great Lakes basin through close cooperation with the States and local agencies. The following is a brief description of some of the activities being taken in carrying out the agency's responsibilities. Particular reference is made to those activities relevant to Lake Superior and its drainage basin.

Water Quality Standards

The Federal Water Pollution Control Act as amended by the Water Quality Act of 1965 authorizes the State and the Federal Governments to establish water quality standards for interstate waters. The water quality standards submitted by the States are subject to review by the Department of the Interior and if found consistent with the intent of the Act, are approved also as Federal standards by the Secretary of the Interior. Water quality standards include water use classifications, criteria necessary to support these uses and a plan for implementation and enforcement.

As part of the adoption procedure, public hearings are held to elicit citizens' views on proposed standards and to ascertain popular wishes as to the use of specific areas of lakes and streams. This action precedes formal State adoption of the standards.

Water quality standards have been adopted by the Lake Superior basin States under provisions of the Water Quality Act of 1965 and have been approved by the Secretary of the Interior. Michigan's temperature criteria as well as portions of Minnesota's standards have been excepted from approval. Figure 6 shows the major interstate waters of the Lake Superior basin, and Appendix B lists the criteria adopted by the States of Michigan, Minnesota and Wisconsin for the open waters of Lake Superior. A copy of the complete set of each State's standards is available from the appropriate State agency.

In addition to interstate standards, Michigan, Minnesota and Wisconsin have also adopted statewide intrastate water quality standards.

Lake Superior and many of the tributary waters have long been noted for excellent water quality and the resultant beneficial uses. Commitments to the preservation of existing high quality waters will play an important role in the preservation of the waters in the Lake Superior basin. The Lake Superior States have adopted policy statements establishing their intent to protect the present high quality of the interstate waters.

CONSTRUCTION GRANT PROJECTS

LEGEND:

- ● Completed Projects

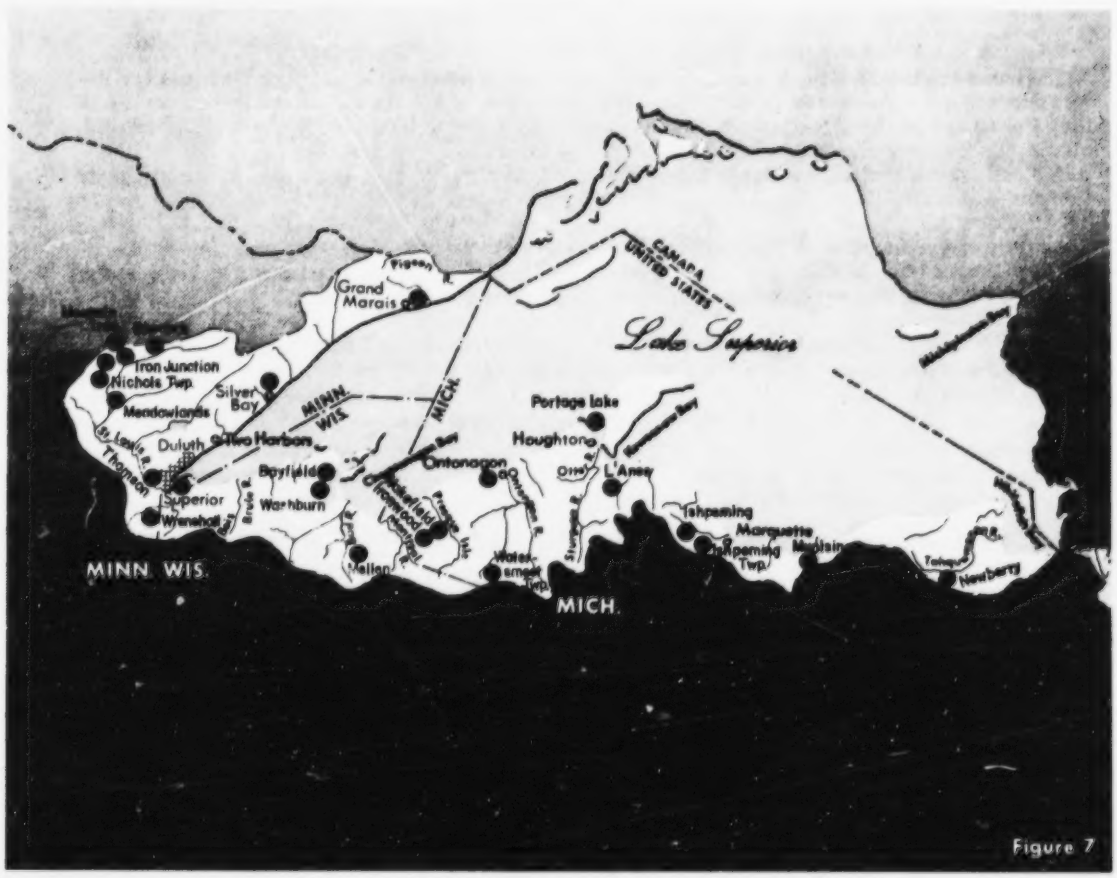


Figure 7

Great Lakes - Illinois River Basins Project

The Great Lakes - Illinois River Basins (GLIRB) Project was established in 1960 as a special task force in what is now the Federal Water Pollution Control Administration. With headquarters in Chicago, the project was charged with developing comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof in the Great Lakes, the Illinois River, and their tributaries.

The major objectives of the comprehensive program developed by the GLIRB Project in cooperation with other Federal agencies, with State water pollution control agencies and interstate agencies, and with the municipalities and industries involved were:

- Identification of the causes of water pollution and the effects of such pollution on the quality of water resources and on beneficial uses.

- The development of agreements on the desired beneficial uses and the water quality required to accommodate those uses.

- The development of water quality control measures to achieve the desired objectives, including the establishment of a timetable for their accomplishment.

- Provision of the mechanism for carrying out program objectives, including continuing surveillance for the purpose of updating the programs to accommodate changing technology and changing water quality needs.

Through reorganization of the FWPCA, the fulfilling of the major objectives of GLIRB ceased being the mission of a specific project. The objectives are being fulfilled under the total FWPCA program.

The established timetable of the GLIRB Project was such that only limited emphasis was placed upon the Lake Superior basin prior to the reorganization. The major accomplishment of the project with respect to the Lake Superior basin was the lake current study which is described in another section.

Construction Grants

With the enactment of the Federal Water Pollution Control Act of 1956, the Federal Government established a Federal sewage treatment works construction grants program to help finance the building of municipal sewage treatment plants. The Federal Government recognized that wastes discharged from municipal sewers are one of the major causes of water pollution. The growth of population and industry, coupled with the backlog of needed treatment works, resulted in a situation that called for increased treatment plant construction at the local level.

Since the 1956 Act, a total of 26 Federal grants have been made to communities in the Lake Superior basin to help build required sewage treatment facilities. Figure 7 locates these grants. Grant funds involved in these projects have totaled over $2.9 million in support of total project expenditures in excess of $8.8 million. All the Federally-assisted grant projects have been completed and placed in operation.

The Construction Grants Section of the Federal Act has been amended three times since its initial 1956 passage. The trend of financial assistance has been upward with each amendment. Today's legislation enables municipalities to qualify for consideration for a basic Federal grant of 30 percent of the eligible cost of a project. A grant of 40 percent can be made in those States which agree to match the basic 30 percent Federal grant. The Federal grant may be increased to 50 percent if the State agrees to pay at least 25 percent of the project cost and enforceable water quality standards have been established for the waters into which the project discharges. A grant may be increased by 10 percent, to 33, 44 or 55 percent, as appropriate,

if the project is certified by a metropolitan or regional planning agency as conforming with a comprehensive metropolitan area plan.

All three States in the Lake Superior basin either have legislation to qualify their municipalities for consideration for the higher grant percentages or have introduced enabling legislation into their State Legislatures. In November 1968, Michigan electors, by a three to one margin, authorized the sale of $335 million worth of bonds for purposes of assisting communities in improving existing and constructing new waste treatment plants; $50 million of this total bond program is to be used for sewer construction assistance for communities without sewers which are contributing to an existing pollution problem and have low property valuation. A draft copy of a State law to implement the State grant bond issue which will spell out the details of administrating and funding specific projects has been completed. Passage of this legislation is expected in the near future.

Wisconsin provides financial assistance of not less than 25 percent or more than 30 percent of the cost of construction of waste treatment facilities. Wisconsin statutes authorize a sum sufficient appropriation up to $6 million per year.

In addition to this program Governor Knowles of Wisconsin has proposed an Outdoor Resources Action Plan - 200. This plan would establish a $200 million bonding program, of which $144 million would be used for construction of sewage treatment facilities. The plan was approved by the citizens of Wisconsin in an advisory referendum. Implementation details are currently in progress.

In Minnesota, a $20 million statewide bonding program to aid local communities with 30 percent of construction costs has been proposed by Governor LeVander. The State fund would be a grant to municipalities unless or until the Federal Government appropriates sufficient money to fully fund the presently authorized Federal program. At that time Federal funds going to a municipality would reimburse the State. A bill to implement this $20 million bonding program has been introduced into the 1969 session of the Minnesota State Legislature. A second bill has been introduced into the Legislature that would provide for a $6 million per year appropriation for State aid to municipalities. Under this proposal the local communities would be eligible to receive full financial benefit from the Federal program.

Program Grants

Section 7 of the Water Pollution Control Act authorizes an appropriation of $10 million annually for Fiscal Years 1968-71 for grants to State and interstate agencies to assist them in meeting the costs of establishing and maintaining adequate pollution control programs. Each State is allotted $12,000, and the remainder of the funds are distributed on the basis of population, financial need, and the extent of the water pollution problems facing the State. Since program grants were first authorized in Fiscal Year 1957, a total of $4,433,930 in Federal funds has been allocated to the Lake Superior States for their pollution control programs. By June 1969, Michigan will have received approximately $2,158,273; Minnesota, $1,013,585; and Wisconsin, $1,262,072. During the current fiscal year Michigan is allocated $338,500; Minnesota, $148,000; and Wisconsin, $185,500.

Research, Development and Demonstration Grants

The Research, Development and Demonstration Program is mission oriented, employing the use of grants and contracts for investigations and demonstrations relating to the solution of problems confronting the attainment or retention of clean water. The program deals with the full range of water quality problems -- from pollution definition and control to water resources management and planning.

The Federal Water Pollution Control Act specifically authorizes projects concerned with (a) storm and combined sewers; (b) advanced waste treatment and joint treatment systems for mu-

nicipal and industrial wastes; and (c) methods for prevention of pollution by industry, including treatment of industrial wastes.

In addition, research, training, demonstration, and research fellowship grants are available for the intended purpose to encourage and assist appropriate agencies, institutions, and individuals in the conduct of studies and training which will achieve clean water.

The information being gathered through the above programs will have a wide range of applicability and therefore will be of use in pollution control actions in the Lake Superior basin.

An intramural research program of the FWPCA is carried out in eight ongoing laboratories located across the country. Within the Great Lakes basin, the Administration has established the National Water Quality Laboratory at Duluth, Minnesota. The mission of this laboratory is to determine permissible limits of water quality for any water use and the impairment that can be expected if these limits are exceeded.

In addition to the above, the Federal Water Pollution Control Act specifically authorizes the Federal Water Pollution Control Administration to conduct research and technical development work, and make studies with respect to the quality of the waters of the Great Lakes.

Federal Installations

The Federal Government has not overlooked the pollution hazards created by its own activities. By Executive Order 11288, President Johnson directed the heads of the departments, agencies, and establishments of the Executive Branch of the Government to provide leadership in the nationwide effort to improve water quality.

Federal installations in the Lake Superior basin have initiated pollution abatement programs in accordance with the Order. Excluding those facilities that discharge to municipal systems there are approximately 124 installations within the basin. These are distributed as follows: Michigan 73, Minnesota 37, and Wisconsin 14. The size of the installations vary from camp and picnic grounds at Federal parks to major military installations such as Air Force Bases. These installations discharge waste after varying degrees of treatment to ground or surface waters of the basin. Some of the smaller installations provide no treatment at present. Tabulated in Appendix A of this report is an inventory of these installations showing the waste treatment provided and the status of pollution abatement.

The more significant Federal vessels which frequent the waters and the harbors of Lake Superior are also listed in the Appendix. The U.S. Coast Guard, Navy, and Army Corps of Engineers are all acutely aware of the problems associated with vessel pollution. They are actively pursuing abatement and research and development programs in an effort to obtain waste treatment devices suitable for shipboard use.

All Corps of Engineers vessels and floating plants (tugs, dredges, derricks, etc.) operating in Lake Superior have been fitted with macerator/chlorinator units. Efforts are being made to insure that these devices will be replaced with upgraded disposal units such as holding tanks at the earliest possible date.

Federal water resources projects and facilities and operations supported by Federal loans, grants, or contracts are also included in Executive Order 11288. Water resource projects must be designed, constructed, and operated in a manner which will reduce pollution from such activities to the lowest practicable level.

The head of each Federal department, agency and establishment has been directed to conduct a review of the loan, grant, and contract practices of his own organization to determine to what extent water pollution control requirements set forth in the Order should be adhered to by borrowers, grantees, or contractors. This review has resulted in practices designed to

reduce water pollution in various programs. Urban renewal projects now require the construction of separate storm and sanitary systems rather than combined sewers. The nationwide highway construction program financed with Federal funds and administered by the Bureau of Public Roads, is now being conducted in accordance with practices aimed at preventing water pollution, either during construction or in operation and maintenance. The various agencies have consulted with the Federal Water Pollution Control Administration in an effort to insure maximum consideration of water quality in their activities.

This Order represents a major step forward in the battle to preserve and enhance quality of our Nation's waters. It has sparked a keen awareness on the part of Government officials of the need for corrective action and vigorous abatement programs. The effort being shown by these various Federal agencies provides leadership in the nationwide quality improvement program.

Technical Programs

The Regional Technical Program provides technical assistance in solving pollution problems to Federal, State, and local agencies, and to industry. Current technical assistance projects affecting Lake Superior include:

1. Participation with the Corps of Engineers in a joint study of the water pollution problems associated with dredging. This includes collection and analysis of samples of bottom sediments from Lake Superior harbors.

2. Participation in the International Joint Commission study of the feasibility of further regulation of the levels of the Great Lakes, including Lake Superior. The object of such further regulation would be to reduce damages resulting from excessively high or low lake levels.

3. Participation in the Department of the Interior study concerning the effects on water quality by the discharge of taconite tailings.

The Technical Program also has responsibility for surveillance of water quality throughout the Region for purposes of water quality standards compliance, basic planning, and long-term water quality trends. A Regionwide surveillance plan is being developed in cooperation with the State water pollution control agencies which will include the streams of the basin and the lake itself.

Basin planning for water pollution control and water quality management is also a responsibility of Technical Programs. This includes inhouse planning studies, participation in the Great Lakes Basin Commission Type I, or framework study, and the administration of the planning grants program authorized by the Federal Water Pollution Control Act, as amended.

Public Information

The Public Information Program of the Federal Water Pollution Control Administration is designed to present facts about water pollution control to the news media, interested groups and organizations, and the public, generally. The program serves the public's right to know what FWPCA is doing and trying to accomplish. It also serves those who need particular information in order to participate effectively in water pollution control programs.

STATE WATER POLLUTION CONTROL PROGRAMS

Michigan, Minnesota and Wisconsin each have water pollution control programs which provide for surveillance and enforcement, surveys and special studies and long range water quality management planning activities. Their programs also include review of municipal and industrial waste treatment plant plans and specifications for conformity with Federal, State and local pollution control regulations, review of treatment plant maintenance and operation procedures and plant efficiencies and technical assistance in waste treatment problems to both municipalities and industries. Each State has a program for the certification of waste treatment plant operators and a commensurate program for the training of operators to meet certification requirements, and each State conducts a public information program for the dissemination of water pollution control news to the general public as well as special information to those professionally interested.

Michigan

The Michigan Water Resources Commission planned in Fiscal Year 1969 to continue to emphasize the enforcement of pollution abatement with subsequent water quality improvement and prevention of water quality degradation. The Commission is charged with control over the pollution of any waters of the State and the Great Lakes and to protect and conserve the water resources of the State. Michigan's plans call for expanded action in many elements of water pollution control. The program of establishing intrastate water quality standards is to be completed in Fiscal Year 1969, and with the passage of a $335 million bond issue, the State is now able to provide 25 percent grants to municipalities for the construction of waste treatment facilities.

The State's water quality surveillance program is accelerating with plans for automated sampling analysis and data processing. Commission rule concerning watercraft pollution will go into effect January 1, 1970, and new statutory requirements for certifying industrial and commercial waste treatment operators will require a new agency program for training and certification of those operators. The Michigan Water Resources Commission chairs an interdepartmental committee on water and related land use planning.

Michigan's current fiscal year water pollution control budget is $995,000 and approximately 74 man-years are assigned to that effort. Increases are proposed in Fiscal Year 1970 which will contribute further to the Commission's ability to assure protection of the State's waters.

In addition to the above, the Michigan Department of Public Health through its Waste Water Control Section, expends $130,000 and approximately 12 man years on pollution control.

Minnesota

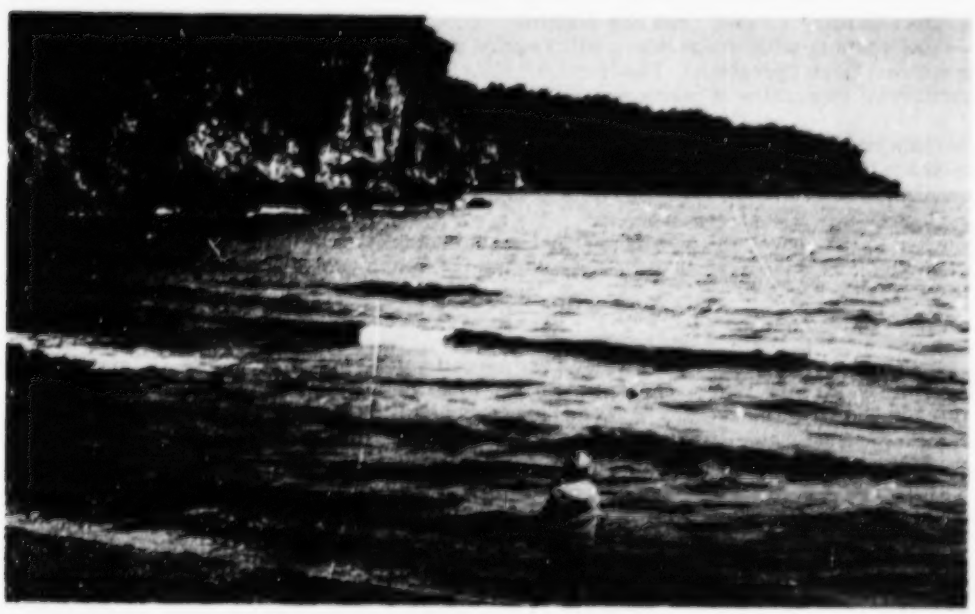
The Minnesota Pollution Control Agency has planned a program of expansion and special contracts in Fiscal Year 1969. The Agency has overall responsibility, at the State level, for managing the quality of the waters of Minnesota by controlling the sources of pollution which may adversely affect water quality. Minnesota's program includes several specific activities to improve the water pollution control effort. Effluent standards have been adopted for all waters of the State and more waters are to be monitored on a more frequent basis throughout the State. A systematic program of adopting water use classifications and establishing water quality standards is underway for intrastate waters. The State's criteria for determining priorities for Federal grants for the construction of municipal waste facilities enables better distribution of funds to areas where pollution problems are greatest. The important aspect of efficient plant operation will be improved with the planned use of regional operator training schools, although certification is not mandatory in Minnesota. A bill has been introduced into the current session of the legislature that would require mandatory certification. The Agency's plans to expand its staff and activity in all elements of the water pollution control program is a significant expression of the State's concern.

Currently Minnesota's annual water pollution control budget is $717,476 and approximately 46 man-years are assigned to that effort. The Fiscal Year 1969 budget and the proposed Fiscal Year 1970 budget are significantly higher than previous years, and an increase over present levels of about 12 man-years is projected for Fiscal Year 1970.

Wisconsin

The Wisconsin Department of Natural Resources serves as the central unit of State government to protect, maintain and improve the quality and management of the waters of the State and to organize a comprehensive program for that purpose. Wisconsin's Fiscal Year 1969 program includes many activities which are an expansion of the State's effort. Intrastate water quality standards have been adopted and a system of effluent charges for the control of water pollution is being studied. Plans call for at least annual inspection of all municipal, industrial and State operated sewage treatment plants. The mandatory certification of waste treatment plant operators recently went into effect; and in keeping with that program, the operator training program is being significantly upgraded and expanded. As a step in a program of flood plain and shoreland management, the State is currently overseeing local administration of ordinances and development of flood plain information. The water resources planning activity is also scheduled for expansion to provide plans for each of the State's regions.

In Fiscal Year 1969 Wisconsin's water pollution control budget is $1,879,800 and 68 man-years are assigned to that effort. Projections for Fiscal Year 1970 call for increases which will further expand the State's water pollution control effort.



We conserve so that our own and future generations will be able to enjoy...

Congressman Wayne N. Aspinall Colorado

V. WATER QUALITY CRITERIA

The quality of water in Lake Superior surpasses that of virtually all other major lakes of the United States. The extremely low dissolved and suspended solids, the very cold temperatures, the extreme clarity, and the high oxygen concentration of the water coupled with the size of the lake, makes a unique natural resource that has no equal in the world.

Most of the lake is uniform in nature, including such indices that normally vary seasonally; as for example, temperature and oxygen. For the most part, the dissolved materials present in the water are those that are contributed by natural causes. Present discharges from tributary streams and man-made outfalls are few in number and mostly small in size, therefore as a general rule only limited areas are adversely affected by them. Except for minimal pesticide contamination, the lake is essentially free of synthetic organic chemicals that cause so many problems in other waters. This existing exceptionally high water quality must be preserved.

Water quality standards have been adopted for Lake Superior by the Lake Superior States and approved by the Department of the Interior. The States assigned their highest use categories to Lake Superior (i.e., public water supply, whole body contact recreation, and cold water fishery). The water quality criteria adopted to protect these designated uses were established using the best available knowledge at that time. Hence, the water quality standards for Lake Superior are the most restrictive adopted by the States of Michigan, Minnesota, and Wisconsin, and are among the most stringent standards nationally.

Additional data concerning water quality criteria specific to Lake Superior waters are now available as a result of recently completed research at the FWPCA's National Water Quality Laboratory at Duluth, Minnesota. The National Technical Advisory Committee on Water Quality Criteria (46) issued a report on April 1, 1968 that provides additional information on water quality criteria. These data can be used as a guide to amend the existing water quality standards on Lake Superior. In accordance with the provisions of the Water Quality Act of 1965, it was anticipated that after the initial setting of standards periodic review and revision would be required to take into account changing technology and advances in knowledge of water quality requirements developed through research.

While data on the existing quality of Lake Superior is not abundant, there have been continuous monitoring stations operated at the Duluth water intake and on the St. Mary's River by the FWPCA's water quality monitoring system. From these activities a reasonable picture is available as to the elemental composition of the water for many of the major constituents.

On the basis of the above, water quality criteria can be developed on the open waters of Lake Superior to reflect more appropriately the uniqueness of the lake. These criteria are presented in Table 3. The rationale for these criteria are presented in Appendix C.

TABLE 3

PROPOSED WATER QUALI Y CRITERIA FOR THE OPEN WATERS OF LAKE SUPERIOR[1]

(Mg/1 unless otherwise specified)

Parameter	90% Value[2]	Maximum Value[3]
Dissolved Oxygen	>10.0	9.0
Turbidity	0.5 JTU	5.0 JTU
Color – Wavelength A_5[4]	0.01 absorbance units	0.05 absorbance units
Wavelength B[5]	0.05 absorbance units	0.25 absorbance units
Total Dissolved Solids	65.0	–
Total Coliform Bacteria	10 per 100 ml	1,000 per 100 ml
Fecal Coliform Bacteri	10 per 100 ml	200 per 100 ml
Detergents (MBAS)	0.1	0.4
Phenol	–	0.001
Ammonia Nitrogen	0.05	0.1
Phosphorus	–	0.01
Iron	0.03	0.1
Cadmium	0.002	0.005
Chromium	0.02	0.05
Copper	0.008	0.012
Lead	0.03	0.05
Nickel	0.015	0.03
Zinc	0.01	0.015
Cyanide	0.002	0.004
Hydrogen Sulfide (as total sulfide measured at bottom-water interface)	0.002	0.02
Taste and Odor – Chloroform Extracts	0.03	0.05
Threshold Odor	1.0	3.0
	Mean Value	**Maximum Value**
Temperature (Surface in top meter)		
January, February, March	2°C	5°C
April, May, June	10°C	18°C
July, August, September	18°C	21°C
October, November, December	8°C	15°C

Depths greater than 120 feet: Never over 6°C

pH – Should remain between 6.8 to 8.5 units

Radioactivity – Recommendations for proposed radiological criteria will be deferred pending development of model criteria by Federal Water Pollution Control Administration, Atomic Energy Commission, and U.S. Public Health Service.

General: For nonpersistent wastes discharged directly to Lake Superior, and for other individual chemicals, the 90% value is 1/20 of the 96-hour TL_m value and the maximum value is 1/10 of the 96-hour TL_m value. For persistent complex wastes and other individual materials, the 90% value is 1/100 of the 96-hour TL_m value and the maximum value is 1/20 of the 96-hour TL_m value.

[1] Zones of tributary influence and mixing zones should not exceed a linear distance equal in feet to the cube root of the discharge in mgd x 500. In these zones other standards may be applicable but in no case can the 96-hour TL_m value be exceeded.

[2] 90% of the values obtained at one location must not exceed this value. (For dissolved-oxygen the stated value is a minimum.)

[3] Maximum value not to be exceeded. (For dissolved-oxygen the stated value is a minimum.)

[4] Wavelength A: 3500-8000 angstroms, 10 centimeters light path.

[5] Wavelength B: 2400-3500 angstroms, 10 centimeters light path.

The solitude, peace and quiet beauty found in many areas around Lake Superior refreshes the spirit of those who seek it.

VI. SUMMARY OF CONFERENCE (FIRST SESSION)

POLLUTION OF THE INTERSTATE WATERS OF LAKE SUPERIOR AND ITS TRIBUTARY BASIN (MINNESOTA - WISCONSIN - MICHIGAN)

May 13-15, 1969 and September 30 and October 1, 1969

On the basis of reports, surveys, or studies, the Secretary of the Interior on January 16, 1969, called a conference in the matter of pollution of the interstate waters of Lake Superior and its tributary basin (Minnesota-Wisconsin-Michigan) under the provisions of section 10 of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.).

The conference was held on May 13-15, 1969, at Duluth, Minnesota. The conference was recessed and reconvened in Executive Session on September 30 and October 1, 1969, at Duluth.

Lake Superior is the largest of the Great Lakes and in terms of surface area is the largest fresh water lake in the world. Lake Superior is approximately 350 miles long and 160 miles wide, with a surface area of 31,820 square miles, 1,333 feet at its maximum depth, and the volume is approximately 3,000 cubic miles. The total shoreline of the Lake is 2,976 miles, with 1,549 miles of the shoreline in Canada and 1,427 miles in the United States. The total Lake Superior drainage basin is 80,511 square miles, of which 37,941 square miles are in the United States. The principal river of the basin is the St. Louis, which has a drainage area of about 3,700 square miles and is an interstate stream that forms part of the Minnesota-Wisconsin boundary.

A portion of the Michigan-Wisconsin boundary is formed by the interstate Montreal River, one of the smaller streams in the basin, draining an area of about 281 square miles. The boundary between Minnesota and the Province of Ontario, Canada, is formed by the Pigeon River. Other principal rivers in the basin are the Bad River in Wisconsin and the Ontonagon River in Michigan.

On May 13-15, 1969, the following conferees representing the State water pollution control agencies of Minnesota, Wisconsin, and Michigan, and the U. S. Department of the Interior participated in the conference:

MINNESOTA

John P. Badalich	Executive Director Minnesota Pollution Control Agency Minneapolis, Minnesota
F. Wayne Packard	Member Minnesota Pollution Control Agency Minneapolis, Minnesota
Robert C. Tuveson	Chairman Minnesota Pollution Control Agency Minneapolis, Minnesota

WISCONSIN

Thomas Frangos	Administrator, Division of Environmental Protection Wisconsin Department of Natural Resources Madison, Wisconsin
Lester P. Voigt	Secretary Wisconsin Department of Natural Resources Madison, Wisconsin
Theodore F. Wisniewski	Assistant to the Administrator Division of Resource Development Wisconsin Department of Natural Resources Madison, Wisconsin

MICHIGAN

James Kellogg	Administrative Aide to the Honorable William G. Milliken Governor of Michigan Lansing, Michigan
Ralph W. Purdy	Executive Secretary Michigan Water Resources Commission Lansing, Michigan
John E. Vogt	Chairman Michigan Water Resources Commission Lansing, Michigan

U. S. DEPARTMENT OF THE INTERIOR

David D. Dominick Co-Chairman	Commissioner Federal Water Pollution Control Administration U. S. Department of the Interior Washington, D. C.
Carl L. Klein Conference Chairman	Assistant Secretary Water Quality and Research U. S. Department of the Interior Washington, D. C.
Murray Stein Federal Conferee	Assistant Commissioner – Enforcement Federal Water Pollution Control Administration U. S. Department of the Interior Washington, D. C.

At the Executive Session of the conference, held September 30, and October 1, 1969, the conferees were as follows:

MINNESOTA

Howard Anderson	Member Minnesota Pollution Control Agency Minneapolis, Minnesota
John P. Badalich	Executive Director Minnesota Pollution Control Agency Minneapolis, Minnesota
Robert C. Tuveson	Chairman Minnesota Pollution Control Agency Minneapolis, Minnesota

WISCONSIN

Thomas Frangos	Adminstrator, Division of Environmental Protection Wisconsin Department of Natural Resources Madison, Wisconsin
Donald Mackie	Executive Assistant Wisconsin Department of Natural Resources Madison, Wisconsin

MICHIGAN

Ralph W. Purdy	Executive Secretary Michigan Water Resources Commission Lansing, Michigan

U. S. DEPARTMENT OF THE INTERIOR

Dale Bryson	Director, Lake Superior Basin Office Federal Water Pollution Control Administration U. S. Department of the Interior Minneapolis, Minnesota
H. W. Poston	Regional Director Great Lakes Regional Office Federal Water Pollution Control Administration Chicago, Illinois
Murray Stein Chairman	Assistant Commissioner – Enforcement Federal Water Pollution Control Administration U. S. Department of the Interior Washington, D. C.

The Chairman of the conference pointed out that:

1. Under the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.) pollution of interstate waters which endangers the health or welfare of any persons is subject to abatement under procedures described in section 10 of the Federal Act.
2. The first step of these procedures is the calling of the conference.
3. The purpose of these procedures is to bring together representatives of the States and the U. S. Department of the Interior to review the existing situation and the progress which has been made, to lay a basis for future action by all parties concerned, and to give the States, localities, and industries an opportunity to take any remedial action which may be indicated under State and local law.

At the May 13-15, 1969, conference session, statements and reports on the effects of pollution on the interstate waters of Lake Superior from municipal, industrial, and other waste sources, were presented for the conferees' consideration. The conference was recessed on May 15, 1969, to allow the conferees sufficient time for evaluation of the extensive data developed by the conference, with a view toward developing recommendations for corrective measures as would be warranted.

The conference was reconvened in Executive Session on September 30 and October 1, 1969. The following points were considered by the conferees.

1. The distribution of taconite tailings in Lake Superior;
2. Whether the materials in the taconite are soluble and leach out into the waters, and whether these materials have biological or other effects; and,
3. The water quality requirements for the open waters of Lake Superior.

In light of conference discussions, the conferees at the Executive Session reached the following conclusions and recommendations:

CONCLUSIONS

1. Lake Superior is a priceless natural heritage which the present generation holds in trust for posterity, with an obligation to pass it on in the best possible condition.

2. The esthetic value of Lake Superior is of major importance. The Lake's deep blue appearance is a significant tourist attraction.

3. Because of the low mineral content of Lake Superior's waters, man-made changes in the range of parts per billion of heavy metals such as copper, chromium, zinc, and cadmium may have lasting deleterious effects upon the Lake.

4. The extreme clarity and cold temperature of the waters of Lake Superior are a necessity to support its present ecology. A reduction in light penetration will alter the types of life therein. The clarity of the Lake is extremely susceptible to being reduced by pollutants.

5. The portion of Lake Superior shallow enough to provide suitable fish spawning areas is limited to a small band around the shoreline. This area is most susceptible to the influence of natural and man-made sediments. Deposition on the bottom of fine particles discharged to Lake Superior is a threat to the inshore food producing area and to the incubation of important fish species.

6. Water quality criteria, including non-degradation provisions, have been established by the States and approved by the Secretary of the Interior to protect the esthetic value, recreational uses, and the unique aquatic life of the Lake.

7. Lake Superior is an oligotrophic lake. Nutrient values in some areas of the Lake have been reported at levels approaching those commonly associated with nuisance algal growths.

8. Outflow from Lake Superior passes through Lakes Huron, Erie and Ontario. Dissolved persistent substances in this outflow become a part of the waters of these downstream lakes.

9. The discharge of taconite tailings to Lake Superior from the Reserve Mining Company, E. W. Davis Works, has a deleterious effect on the ecology of a portion of the Lake by reducing organisms necessary to support fish life.

10. The quantity of oxygen normally dissolved in water is one of the more important ingredients necessary for a healthy balanced aquatic life. The discharge of treated and untreated municipal and industrial wastes with high concentrations of biochemical oxygen demand has caused oxygen depletion in portions of the St. Louis River, Duluth-Superior Harbor, and Montreal River.

11. Watercraft plying the waters of Lake Superior are contributors of both untreated and inadequately treated wastes in local harbors and in the open Lake, and intensify local pollution problems.

12. Oil discharges from industrial plants, commercial ships and careless loading and unloading of cargoes have despoiled beaches and other recreational areas, coated the hulls of boats and are deleterious to fish and aquatic life.

13. Evidence of bacterial pollution has been reported in the St. Louis River, and Duluth Harbor area in Minnesota; and Superior Harbor area, Ashland inshore area and reaches of the Montreal River in Wisconsin.

14. The maintenance of waterways for commercial and recreational use is a necessary activity. The deposition of polluted dredgings in Lake Superior contributes to the degradation in quality of the Lake's waters.

15. Adverse effects upon water quality and water uses of streams in the red clay area of northwestern Wisconsin are occuring as a result of land runoff from poor land management practices. The sediment contained in the discharges from streams in this area has an adverse effect on Lake Superior.

16. A persistent pollutant entering directly into the waters of Lake Superior or dissolved in the water that feeds the Lake mixes with and becomes an integral part of a significant portion of the Lake water.

17. Discharges of wastes originating in Wisconsin cause pollution of the interstate Montreal River. Discharges of wastes originating in Minnesota and Wisconsin cause pollution of the interstate St. Louis River and Duluth-Superior Harbor. Discharges of inadequately treated wastes originating in Michigan, Minnesota, and Wisconsin cause pollution of Lake Superior. This pollution results from nutrients which fertilize the Lake. These discharges endanger the health or welfare of persons in States other than those in which discharges originate. This pollution is subject to abatement under the provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.).

18. There is presumptive evidence in the record to indicate that the discharges from the Reserve Mining Company endanger the health or welfare of persons in States other than that in which such discharges originate and that this pollution is subject to abatement under the provisions of the Federal Water Pollution Control Act.

RECOMMENDATIONS

It is recommended that:

1. A Technical Committee to evaluate water quality criteria for Lake Superior be formed of the conferees and such representatives as they may designate, within two weeks of the Executive Session. The purpose of the Committee is to develop particular water quality criteria as guidelines for modification of the Federal-State Water Quality Standards. The provision of the necessary secretarial assistance to the Committee will be the responsibility of the Federal conferee. The Committee may coordinate its activities with other committees or agencies, or engage consultants, as it determines appropriate. At the next session of the conference, the Committee will report to the conferees on recommendations agreed upon for changing or modifying existing water quality criteria to reflect desired quality conditions in Lake Superior.

2. The FWPCA and the States keep the discharge of taconite tailings to Lake Superior from the Reserve Mining Company, E. W. Davis Works, under continuing surveillance and report to the conferees at six month intervals on any findings that interstate pollution is occurring or is likely to occur.

3. Reserve Mining Company be requested to undertake further engineering and economic studies relating to possible ways and means of reducing by maximum practicable extent the discharge of tailings to Lake Superior and submit a report on progress to the Minnesota Pollution Control Agency and the conferees within six months of the date of issuance of the Summary of Conference by the Secretary of the Interior. This report is to include a tentative timetable for necessary action. Lake sampling and effluent and operational information shall be furnished monthly by the Reserve Mining Company to the Minnesota Pollution Control Agency. Reserve Mining also is to inform the Minnesota Pollution Control Agency of the line of study they intend to pursue, and the Minnesota Agency will make this information available to the conferees.

4. The FWPCA and the States substantially strengthen water quality surveillance plans for the Lake Superior Basin to insure that plans are sufficiently sensitive to monitor changes in water quality. The FWPCA and the States are requested to report to the conferees at the next session of the conference concerning their program.

5. Secondary biological waste treatment or its equivalent be provided by all municipalities discharging directly to or affecting Lake Superior or its bays or harbors or interstate tributary streams. This action is to be accomplished by January 1974 or earlier if required by Federal-State Water Quality Standards.

6. Continuous disinfection be provided throughout the year for all municipal waste treatment plant effluents which are discharged to or affect Lake Superior or its bays or harbors or interstate tributaries. This action is to be accomplished as soon as possible and not later than May 1970.

7. Continuous disinfection be provided for industrial effluents containing pathogenic organisms or organisms which indicate the presence of such pathogens which are discharged directly to or affect Lake Superior or its bays or harbors or interstate tributaries. This action should be accomplished as soon as possible and not later than May 1970.

8. * Waste treatment be provided by municipalities to achieve at least 80 percent reduction of total phosphorus from each State. This action is to be accomplished by January 1975 or earlier if required by Federal-State Water Quality Standards. At the next session of the conference, the conferees will present a detailed time schedule for their proposed programs.

9. Discharges of compatible industrial wastes to municipal sewer systems be encouraged. Industries not connected to municipal sewer systems provide treatment equivalent to that of municipalities so as not to cause degradation of Lake Superior water quality. This action is to be accomplished by January 1974 or earlier if required by Federal-State Water Quality Standards.

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* Mr. John Badalich, a Minnesota conferee, objected to this recommendation pointing out that Minnesota has established a program for phosphate removal with effluent standards for individual waste sources.

10. Each State water pollution control agency make necessary corrections to the list in Appendix A (U. S. Department of the Interior report "An Appraisal of Water Pollution in the Lake Superior Basin", April 1969) of municipal and industrial waste discharges to the Lake Superior Basin. In addition, information should be provided on each source to indicate whether it discharges pollutants, including nutrients, that have a deleterious effect on Lake Superior water quality. Detailed action plans for treatment of all wastes having deleterious effects should be developed where not already completed. Such plans shall identify the principal characteristics of the waste material now being discharged, the proposed program for construction or modification of remedial facilities, and a timetable for accomplishment, giving target dates in detail. This list shall be presented to the conferees at the next session of the conference.

11. Unified collection systems serving contiguous urban areas be encouraged.

12. Each of the State's water pollution control agencies accelerate programs to provide for the maximum use of area-wide sewage facilities to discourage the proliferation of small treatment plants in contiguous urbanized areas and foster the replacement of septic tanks with adequate collection and treatment.

13. Each State water pollution control agency list the municipalities or communities having combined sewers. The listing should include a proposed plan for minimizing bypassing so as to utilize to the fullest extent possible the capacity of interceptor sewers for conveying combined flow to treatment facilities. The States are requested to report on the listing of municipalities at the next conference session. Construction of separate sewers or other remedial action to prevent pollution from this source is to be completed by December 31, 1979, or earlier if required by Federal-State Water Quality Standards.

14. Existing combined sewers be separated in coordination with all urban reconstruction projects except where other techniques can be applied to control pollution from combined sewer overflows. Combined sewers should be prohibited in all new developments.

15. The States institute necessary controls to ensure that the concentration of DDT in fish not exceed 1.0 micrograms per gram; DDD not exceed 0.5 micrograms per gram; Dieldrin not exceed 0.1 micrograms per gram and all other chlorinated hydrocarbon insecticides, singly or combined, should not exceed 0.1 micrograms per gram, * (limits apply to both muscle and whole body and are expressed on the basis of wet weight of tissue). Other such environmental standards for insecticides in the Lake Superior Basin be established upon agreement by the States and the FWPCA after establishing an intensive monitoring program.

16. Uniform State requirements for controlling wastes from the watercraft under such State's jurisdiction should be adopted. These requirements should generally conform with the requirements approved by the conferees to the Lake Michigan (Four State) Enforcement Conference. Commensurate interstate requirements controlling the discharge of wastes from commercial vessels should be the responsibility of the Federal Government. The States and the FWPCA are requested to report on this recommendation to the conferees at the next conference session.

17. The dumping of polluted dredged material into Lake Superior be prohibited.

18. Programs be developed by appropriate State and Federal agencies to control soil erosion in the Basin. The Wisconsin conferees will, before the next session of the conference, distribute information to the other conferees concerning the action plan developed by the Red Clay Interagency Committee, and will report on the activities of the Red Clay Interagency Committee at the next conference session. Following this report the conferees will give this matter further consideration with a view toward making specific recommendations.

19. The discharge of visible oil from any source be eliminated.

20. The FWPCA will proceed in accordance with established Federal policies to secure abatement of pollution at Federal Installations consistent with the recommendations of this conference.

21. The conference will be reconvened in approximately six months, and periodically thereafter, at the call of the Chairman.

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* These limits are designed to protect the well being of the aquatic organisms and are not primarily intended to protect human health.

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